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Supplementary material for

Echolocation and foraging ecology of the bristle-faced free-tailed bat, *Setirostris eleryi*, in central Australia

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Appendix S1. Calculating V_{ae} for an insectivorous bat (after Bullen *et al*. 2016)

Symbols

AR	aspect ratio
b	span (m)
BMR	Basal metabolic rate (W)
C_D	three dimensional lifting surface drag coefficient = $2\ D / \rho / S_{ref} / V^2$
C_d	two dimensional airfoil section drag coefficient
C_L	three dimensional lifting surface lift coefficient
C_l	two dimensional airfoil lift coefficient
f_w	wingbeat frequency (Hz)
g	acceleration due to gravity = 9.81 m s^{-2}
m	mass (kg)
P	power (W)
q	dynamic pressure = ½ ρ V_{true}^2 (N m^{-2})
Re	Reynolds number
RMR	Resting metabolic rate (W)
S	area of surface producing lift or drag (m^2)
V	flight speed of the bat (m s^{-1})
$V_{eff-max}$	the top of the best efficiency speed-range
θ	wingbeat amplitude (degrees)
ρ	air density = 1.2256 kg m^{-3} at sea level and 15^{O} C

Subscripts

b	bat
body	body
ear	ear
h	heart
head	head
h/t	tail membrane (uropatagium)
ind	indicated
max	maximum condition
mech	mechanical
pro	profile

par parasitic
ref reference condition
true true airspeed (speed of the airflow past the bat)
w wing (includes wing, head, body and ears unless specified)
wr wrist

Compiling airframe parameters for an air-superiority insectivore (after Bullen & McKenzie 2007, 2008).
From Fig. 6, *S. eleryi* airframe reference parameter values are: m_{bat} 0.0056 kg, m_h $4.65*10^{-4}$ kg (0.83% of m_{bat}), S_{ref} 0.0093 m^2, b_{ref} 0.2699 m, AR 7.85, WL 6.09 Nm^{-2}, b_{wr} 0.1259 m and S_{ear} 0.00013 m^2; parasitic reference lift area values are S_{head} 0.00023 m^2, $S_{h/t}$ 0 and $S_{w\text{-}vortex}$ 0; drag area values are: S_{body} 0.000166 m^2 and $S_{h/t}$ 0.00082 m^2.

Aerobic muscle power calculation
The aerobic flight muscle power output is calculated from the maximum usable oxygen volume (Vol O_{2max}) reaching the muscles. The maximum oxygen uptake by the bat's metabolism and flight muscles is estimated by multiplying the maximum blood volume ($Vol_{b\ max}$) by the arteriovenous difference in O_2 saturation and the blood's haemoglobin fraction:

$$Vol_{b\ max} = 212.7 m_h^{0:879} \quad = 15.02 \text{ ml min}^{-1}$$

Which, for insectivores, then converts to a Vol O_{2max} of 3.14 ml min^{-1} (after Bishop 1997).
Then the maximum aerobic power available to the flight muscles is estimated from:

$$P_{aerobic\ max} = \text{Vol } O_{2max} (\text{ml min}^{-1})\ 19.7 / 60 \qquad \text{(after Bishop 1997)}$$

Calculating mechanical power (from Bullen *et al.* 2014)**:**

$$P_{mech} = P_{ind} + P_{pro} + P_{par} \qquad \text{(W)}$$

where,

Induced power (P_{ind}) = $1.2\ V_{true}\ (C_L^2 / \pi / AR)\ q\ S_{ref}$

Profile power (P_{pro}) = $q\ S_{w+h/t}\ C_{dpro}\ V_w$

Parasitic power (P_{para}) = $q\ V_{true} \sum (C_{Dpara\text{-}appendage}\ S_{appendage})$

where,

$C_L = 2\ m_{bat}\ g / \rho / S_{ref} / V_{true}^2$

$S_{appendage}$ is the drag-producing area of the head, body, ears or tail (but not wing)

$V_w = \sqrt{[V_{true}^2 + (b_{wr}\ \theta_w\ f_w)^2]}$

$f_w = 5.54 - 3.068 \log_{10} m_{bat} - 2.857 \log_{10} V_{true}$

$\theta_w = 56.92 + 5.18\ V_{true} + 16.06 \log_{10} S_{ref}$ (degrees)

at Reynolds number (Re) = 42,000,

$C_{dpro} = 0.039\ C_l^2 - 0.056\ C_l + 0.045$ for air superiority insectivores such as *S. eleryi*, and at V_{ae}, $C_l \sim C_L$

C_{dpro} is then corrected for Reynolds number using:

$\Delta C_{d@Re} = 0{:}0038\ [\text{Ln}(Re / 1000) - \text{Ln}(42)]$

$C_{Dpara\text{-}appendage}$ comprises:

$C_{Dpara\text{-}head+body} = 0.25$ (for aerodynamically clean bats with silky fur, such as *S. eleryi*),

$C_{Dpara\text{-}ears} = 0.04$ (bats with ear type-0, -1 or -2), and

$C_{Dpara\text{-}h/t} = 0.05$ (type-2 uroptagium).

To convert mechanical power to metabolic power (W).
Physiologically, the total metabolic power (in Watts) required by the bat for level flight at V_{ae} is given by:

$$P_{met} = \{[(P_{mech})/\eta] + RMR]\ K$$

where,

$\eta = [1.52 \text{ Ln } (m_{bat}) + 11.44] + [1.3 (V_{true} - V_{eff\text{-}max})]$ %

K = physiological power fraction = 1.10

RMR = 1.3 BMR / 179 (ml O_2h^{-1}) (W)

and,

Ln BMR = 0.801 Ln m_{bat} (g) + 0.851 (ml O_2h^{-1})

Deriving V_{ae} from the model

V_{ae} is calculated from $V_{eff\text{-}max}$, the top of the best efficiency speed-range (after Bullen *et al*. 2016) or for air-superiority insectivores, can be approximated by V_{mr}, the mid-point of this range (from p. 62 in Pennycuick 2008).

$$V_{mr} = (k^{0.25} * m_b^{0.5} * g^{0.5}) / (1.2256^{0.5} * A^{0.25} * S^{0.25})$$

where,

$A = \sum (C_{Dpara\text{-}appendage}\, S_{appendage})$

$S = \pi\, b_{re}^2 / 4$

k (induced power factor) = 1.2 (see Bullen *et al*. 2016)

V_{ae}–'maximum aerobic speed' is the speed where the maximum aerobic power available to the species ($P_{aerobic\ max}$ from above) is substituted into the metabolic power equations (P_{mech} converted to P_{met}) and iteratively resolved for speed.

Additional references

Bishop, C. M. (1997). Heart mass and the maximum cardiac output of birds and mammals: implications for estimating the maximum aerobic power input of flying animals. *Philos. Trans. R. S. Lond.* B. **352**, 447–456.

Bullen, R. D., McKenzie, N. L. and Cruz-Neto, A. P. (2014). Aerodynamic power and mechanical efficiency of bat airframes using a quasi-steady model. *CEAS Aero. J.* **5**, 253–264.

Pennycuick, C.J. (2008). Modelling the flying bird (Vol. 5). Elsevier.

Table S1. The averaged spectral statistics of the sequences used as data points for the discriminant function analysis. Parameter codes are explained in the caption to Table 2.

Sequence Code	Observed 'species + shape group'	avF_{peak}	av$Q$	avDur	avF_{max}	avf_{WB}
Se1 66	Se1	38.3	53.9	6.7	44.3	8.0
Se1 69	Se1	38.4	64.1	6.0	44.5	8.0
Se1 32	Se1	38.5	58.7	6.0	41.0	7.5
Se1 34	Se1	38.6	50.9	6.0	42.5	7.4
Se1 103	Se1	38.6	53.1	4.5	45.5	8.8
Se1 98	Se1	38.6	70.5	5.8	45.5	8.8
Se1 94	Se1	38.6	62.3	5.3	45.3	9.0
Se1 120	Se1	38.8	65.3	4.7	46.0	8.4
Se1 116	Se1	39.2	42.7	4.3	48.3	9.3
Se1 111	Se1	39.4	80.4	5.0	43.5	10.6
Se1 6	Se1	40.0	66.0	7.0	45.0	8.8
Se1 124	Se1	40.7	64.7	5.0	49.2	8.7
Se1 108	Se1	40.7	64.6	4.3	45.3	10.3
Se1 129	Se1	40.7	83.2	5.3	47.8	9.5
Se1 74	Se1	40.8	50.4	4.0	48.0	9.1
Se1 72	Se1	40.8	51.8	4.5	49.5	10.3
Se1 133	Se1	41.0	69.8	5.0	47.3	9.6
Se1 151	Se1	41.2	81.2	6.0	47.7	9.3
Se1 179	Se1	42.4	67.3	4.7	48.7	9.6
Se2 59	Se2	39.4	33.5	4.5	62.8	8.7
Se2 138	Se2	39.4	47.0	6.2	47.4	10.0
Se2 24	Se2	39.7	39.1	4.9	54.9	8.9
Se2 173	Se2	39.9	57.4	4.5	53.0	10.1
Se2 183	Se2	40.2	34.8	5.2	56.0	7.7
Se2 1	Se2	40.4	40.9	6.8	48.8	8.7
Se2 37	Se2	40.5	31.9	5.3	61.0	9.3
Se2 195	Se2	40.7	41.2	4.8	53.3	9.1
Se2 86	Se2	40.7	30.4	5.3	50.7	8.0
Se2 167	Se2	41.0	74.7	5.2	52.8	9.4
Se2 17	Se2	41.0	34.9	4.2	62.8	8.4
Se2 83	Se2	41.0	44.0	4.7	54.3	9.1
Se2 46	Se2	41.0	52.6	8.0	52.4	9.6
Se2 191	Se2	41.3	40.4	4.8	53.6	9.5
Se2 76	Se2	41.5	50.4	5.3	54.7	9.2
Se2 164	Se2	41.5	61.7	4.3	49.3	10.0
Se2 158	Se2	42.0	62.7	4.7	54.0	8.7
Se2 161	Se2	42.1	60.9	4.5	54.5	9.7
Se2 13	Se2	42.5	22.5	5.3	68.3	6.6
Se2 176	Se2	42.6	55.4	3.3	51.7	8.9
Se2 10	Se2	42.8	27.6	6.0	62.0	6.6
Se2 53	Se2	42.9	25.8	5.8	59.2	8.6
Sg2 345	Sg2	35.8	58.7	9.0	49.5	10.2
Sg2 256	Sg2	36.3	60.5	7.5	41.0	10.3

Sg2 390	Sg2	36.5	39.6	6.8	40.8	10.5
Sg2 144	Sg2	38.5	42.5	6.7	45.2	9.4
Sg2 252	Sg2	36.6	44.1	7.8	40.8	9.1
Sg2 341	Sg2	36.9	50.4	6.7	48.7	10.6
Sg2 411	Sg2	37.1	60.6	8.0	46.3	10.3
Sg2 546	Sg2	37.3	37.1	6.2	61.9	11.3
Sg2 349	Sg2	37.4	31.6	6.8	60.0	10.6
Sg2 464	Sg2	37.6	44.4	8.9	83.1	10.5
Sg2 405	Sg2	37.7	52.7	7.6	49.4	11.6
Sg2 296	Sg2	37.9	35.1	7.3	49.3	10.6
Sg2 327	Sg2	38.0	34.4	6.0	53.0	11.0
Sg2 332	Sg2	38.0	46.7	6.7	47.3	9.3
Sg2 403	Sg2	38.2	52.3	5.0	45.0	10.6
Sg2 373	Sg2	38.3	31.2	8.0	75.0	9.6
Sg2 397	Sg2	38.3	39.3	5.0	47.0	9.8
Sg2 330	Sg2	38.3	44.8	7.0	45.0	10.6
Sg2 305	Sg2	38.4	49.1	6.0	49.7	9.2
Sg2 289	Sg2	38.5	37.5	7.3	49.1	10.6
Sg2 361	Sg2	38.5	24.8	6.2	55.4	9.8
Sg2 367	Sg2	38.6	33.8	6.4	55.2	11.1
Sg2 378	Sg2	38.7	36.2	6.7	56.3	10.0
Sg2 262	Sg2	38.7	43.0	4.7	50.7	9.3
Sg2 388	Sg2	38.7	26.3	7.0	61.0	9.7
Sg2 308	Sg2	38.7	42.6	6.7	48.3	10.2
Sg2 553	Sg2	38.8	27.8	4.0	50.4	11.0
Sg2 318	Sg2	38.8	36.7	6.8	52.5	10.2
Sg2 375	Sg2	38.9	25.6	5.5	49.5	9.6
Sg2 323	Sg2	39.0	30.7	5.5	53.5	11.9
Sg2 355	Sg2	39.1	22.4	5.6	58.0	10.3
Sg2 259	Sg2	39.2	22.7	4.7	55.0	9.9
Sg2 524	Sg2	39.3	38.6	7.5	79.7	10.5
Sg2 432	Sg2	39.3	37.3	6.7	72.6	11.0
Sg2 513	Sg2	39.4	35.0	5.8	61.2	10.5
Sg2 561	Sg2	39.5	32.3	6.3	65.1	10.6
Sg2 555	Sg2	39.7	24.9	8.2	81.6	10.6
Sg2 266	Sg2	39.7	35.4	5.2	55.9	9.5
Sg2 447	Sg2	40.0	35.5	6.1	68.4	9.8
Sg2 283	Sg2	40.2	18.2	5.0	60.0	12.8
Sg2 426	Sg2	40.2	24.7	5.8	88.3	10.7
Sg2 565	Sg2	40.5	28.0	7.2	84.0	10.3
Sg2 589	Sg2	40.7	20.0	5.3	73.9	10.8
Sg2 416	Sg2	40.7	25.9	6.1	75.2	9.8
Sg2 494	Sg2	40.7	27.1	6.7	100.1	10.3
Sg2 277	Sg2	40.9	13.8	4.0	71.4	10.3
Sg2 572	Sg2	41.1	21.2	5.5	80.9	10.6
Sg2 300	Sg2	41.3	19.5	5.5	56.8	10.8
Sg2 518	Sg2	41.3	30.6	6.4	76.5	10.7
Sg2 382	Sg2	41.9	15.6	4.0	75.6	10.6

Sg2 312	Sg2	41.9	17.6	4.8	58.2	10.7
Sg2 338	Sg2	42.1	17.5	5.0	60.0	10.3
Sg2 336	Sg2	42.3	20.6	5.5	65.0	11.1

Table S2. Posterior probability matrix derived from the discriminant function analysis. *Setirostris eleryi* (*Se*) and *Scotorepens greyii* (*Sg*). Pulse shape abbreviations are explained in Fig. 3: here, 1 = '1 d', 2 = 'sl d' + 'sl d h'. Echolocation sequences that were classified to the incorrect species are prefixed '*' with the relevant probability value boxed.

Sequence code	Observed 'species + shape group'	Predicted shape group		
		*Se*1	*Se*2	*Sg*2
Se1 103	Se1	0.77	0.23	0.00
Se1 108	Se1	0.81	0.19	0.00
Se1 111	Se1	0.98	0.02	0.00
Se1 116	Se1	0.36	0.53	0.11
Se1 120	Se1	0.94	0.06	0.00
Se1 124	Se1	0.81	0.19	0.00
Se1 129	Se1	0.97	0.03	0.00
Se1 133	Se1	0.85	0.15	0.00
Se1 151	Se1	0.92	0.08	0.00
Se1 179	Se1	0.72	0.28	0.00
Se1 32	Se1	0.73	0.27	0.00
Se1 34	Se1	0.50	0.50	0.00
Se1 6	Se1	0.56	0.44	0.00
Se1 66	Se1	0.48	0.51	0.01
Se1 69	Se1	0.86	0.14	0.00
Se1 72	Se1	0.40	0.57	0.03
Se1 74	Se1	0.51	0.49	0.00
Se1 94	Se1	0.85	0.15	0.00
Se1 98	Se1	0.93	0.07	0.00
Se2 1	Se2	0.04	0.91	0.05
Se2 10	Se2	0.01	0.99	0.00
Se2 13	Se2	0.01	0.99	0.00
*Se2 138	Se2	0.03	0.17	0.80
Se2 158	Se2	0.70	0.30	0.00
Se2 161	Se2	0.61	0.39	0.00
Se2 164	Se2	0.69	0.31	0.00
Se2 167	Se2	0.92	0.08	0.00
Se2 17	Se2	0.14	0.86	0.00
Se2 173	Se2	0.72	0.27	0.01
Se2 176	Se2	0.60	0.40	0.00
Se2 183	Se2	0.10	0.90	0.00
Se2 191	Se2	0.10	0.87	0.03
Se2 195	Se2	0.17	0.82	0.01
Se2 24	Se2	0.18	0.73	0.10
*Se2 37	Se2	0.02	0.48	0.50
Se2 46	Se2	0.05	0.86	0.09
Se2 53	Se2	0.00	0.99	0.00
Se2 59	Se2	0.14	0.62	0.23
Se2 76	Se2	0.23	0.77	0.00

Se2 83	Se2	0.21	0.79	0.00
Se2 86	Se2	0.03	0.96	0.00
Sg2 144	Sg2	0.01	0.07	0.92
Sg2 252	Sg2	0.00	0.00	1.00
Sg2 256	Sg2	0.00	0.00	1.00
Sg2 259	Sg2	0.00	0.00	1.00
Sg2 262	Sg2	0.23	0.35	0.42
Sg2 266	Sg2	0.02	0.20	0.78
Sg2 277	Sg2	0.00	0.00	1.00
Sg2 283	Sg2	0.00	0.00	1.00
Sg2 289	Sg2	0.00	0.00	1.00
Sg2 296	Sg2	0.00	0.00	1.00
Sg2 300	Sg2	0.00	0.00	1.00
Sg2 305	Sg2	0.23	0.35	0.42
Sg2 308	Sg2	0.00	0.00	0.99
Sg2 312	Sg2	0.00	0.01	0.99
Sg2 318	Sg2	0.00	0.00	1.00
Sg2 323	Sg2	0.00	0.00	1.00
Sg2 327	Sg2	0.00	0.00	1.00
Sg2 330	Sg2	0.00	0.00	1.00
Sg2 332	Sg2	0.02	0.06	0.92
Sg2 336	Sg2	0.00	0.00	1.00
Sg2 338	Sg2	0.00	0.03	0.97
Sg2 341	Sg2	0.00	0.00	1.00
Sg2 345	Sg2	0.00	0.00	1.00
Sg2 349	Sg2	0.00	0.00	1.00
Sg2 355	Sg2	0.00	0.00	1.00
Sg2 361	Sg2	0.00	0.00	1.00
Sg2 367	Sg2	0.00	0.00	1.00
Sg2 373	Sg2	0.00	0.00	1.00
Sg2 375	Sg2	0.00	0.00	1.00
Sg2 378	Sg2	0.00	0.00	1.00
Sg2 382	Sg2	0.00	0.00	1.00
Sg2 388	Sg2	0.00	0.00	1.00
Sg2 390	Sg2	0.00	0.00	1.00
Sg2 397	Sg2	0.01	0.02	0.97
Sg2 403	Sg2	0.03	0.02	0.95
Sg2 405	Sg2	0.00	0.00	1.00
Sg2 411	Sg2	0.00	0.00	1.00
Sg2 416	Sg2	0.00	0.01	0.99
Sg2 426	Sg2	0.00	0.00	1.00
Sg2 432	Sg2	0.00	0.00	1.00
Sg2 447	Sg2	0.00	0.03	0.97
Sg2 464	Sg2	0.00	0.00	1.00
Sg2 494	Sg2	0.00	0.00	1.00
Sg2 513	Sg2	0.00	0.00	1.00
Sg2 518	Sg2	0.00	0.00	1.00
Sg2 524	Sg2	0.00	0.00	1.00

Sg2 546	Sg2	0.00	0.00	1.00
Sg2 553	Sg2	0.00	0.00	1.00
Sg2 555	Sg2	0.00	0.00	1.00
Sg2 561	Sg2	0.00	0.00	1.00
Sg2 565	Sg2	0.00	0.00	1.00
Sg2 572	Sg2	0.00	0.00	1.00
Sg2 589	Sg2	0.00	0.00	1.00