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SUPPLEMENTARY MATERIAL

Towards a regional call library: Classifying calls of a species-rich bat assemblage in a Bornean karst rainforest

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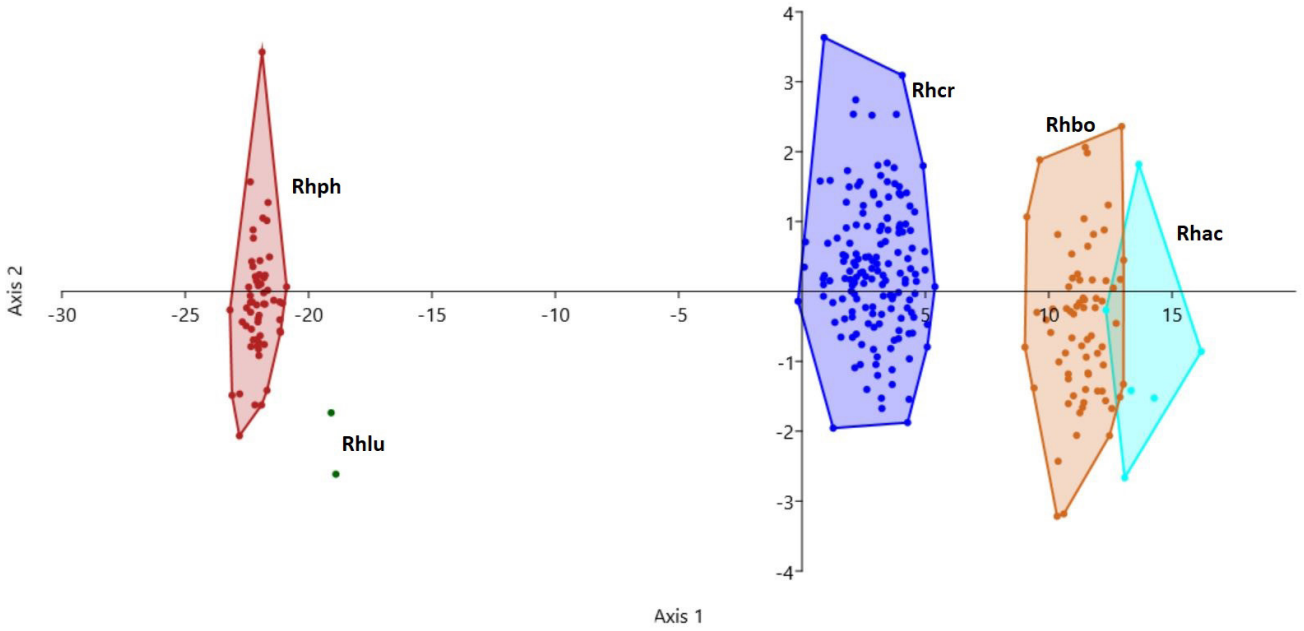

Fig. 1 - Discriminant Function Analysis plot for FM-CF-FM calls (Family Rhinolophidae) recorded in Gunung Mulu National Park. Rhac = *Rhinolophus acuminatus*, Rhbo = *R. borneensis*, Rhcr = *R. creaghi*, Rhlu = *R. luctus*, Rhph = *R. philippinensis.*

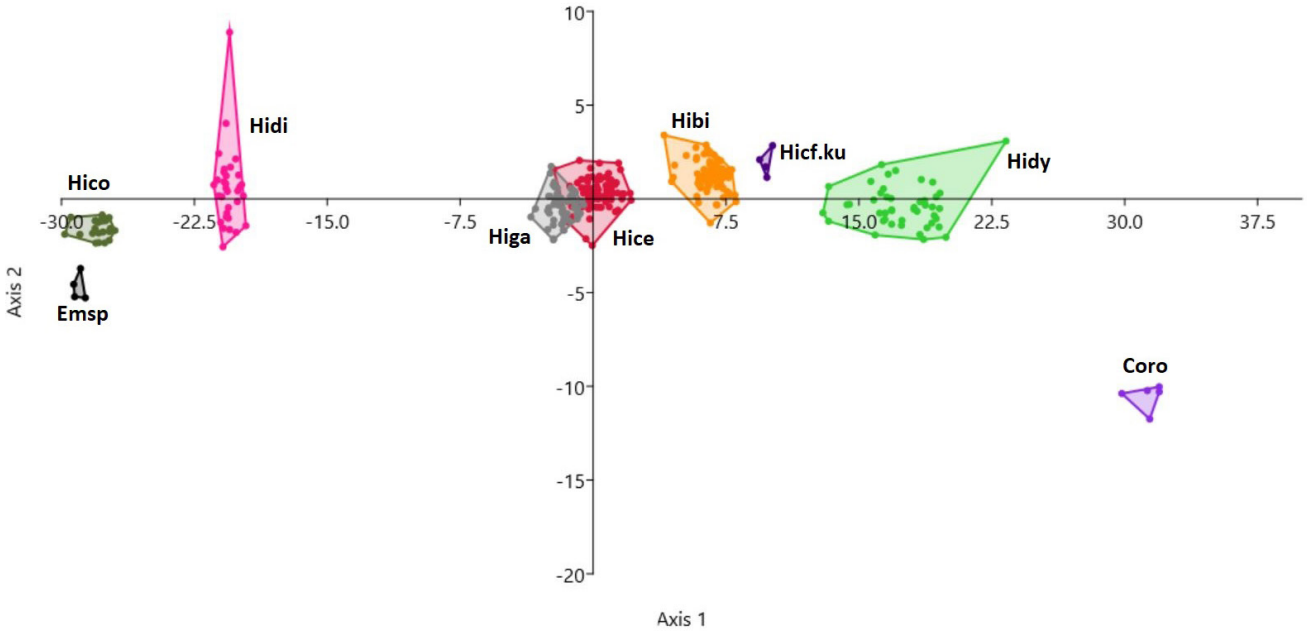

Fig. 2 - Discriminant Function Analysis plot for CF-FM and QCF-MH calls recorded in Gunung Mulu National Park. Hibi = *Hipposideros bicolor*, Hice = *H. cervinus*, Hico = *H. coxi*, Hidi = *H. diadema*, Hidy = *H. dyacorum*, Higa = *H. galeritus*, Hicf.ku = *H.* cf. *kunzi*, Coro = *Coelops robinsoni*, Emsp = *Emballonura alecto/monticola*.

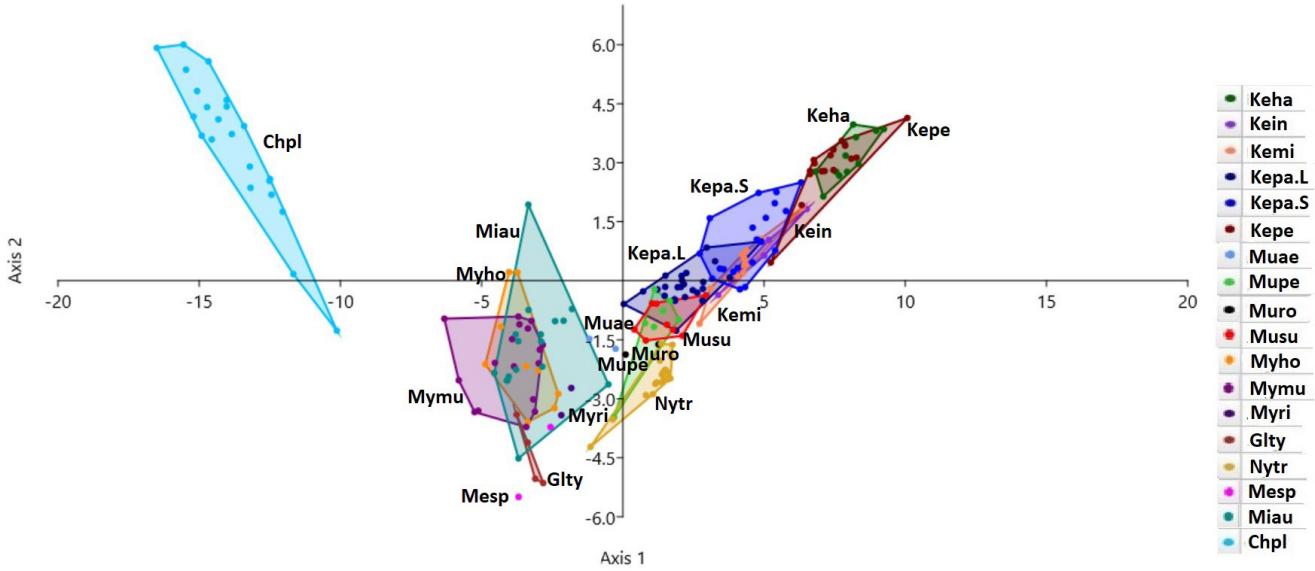

Fig. 3: Discriminant Function Analysis plot for FM-B, FM-MH and FM-QCF calls recorded in Gunung Mulu National Park. Keha = *K. hardwickii*, Kein = *K. intermedia*, Kemi = *K. minuta*, Kepa.L = *K. papillosa* (large form), Kepa.s = *K. papillosa*, Kepe = *K. pellucida*, Muae = *M. aenea*, Mupe = *M. peninsularis*, Muro = *M. rozendaali*, Musu = *M. suilla*, Myho = *M. horsfieldi*, Mymu = *M. muricola*, Myri = *M. ridleyi*, Glty= *G. tylophus*, Nytr = *N. tragata*, Mesp = *M. spasma*, Miau = *M. australis*, Chpl = *C. plicatus*.

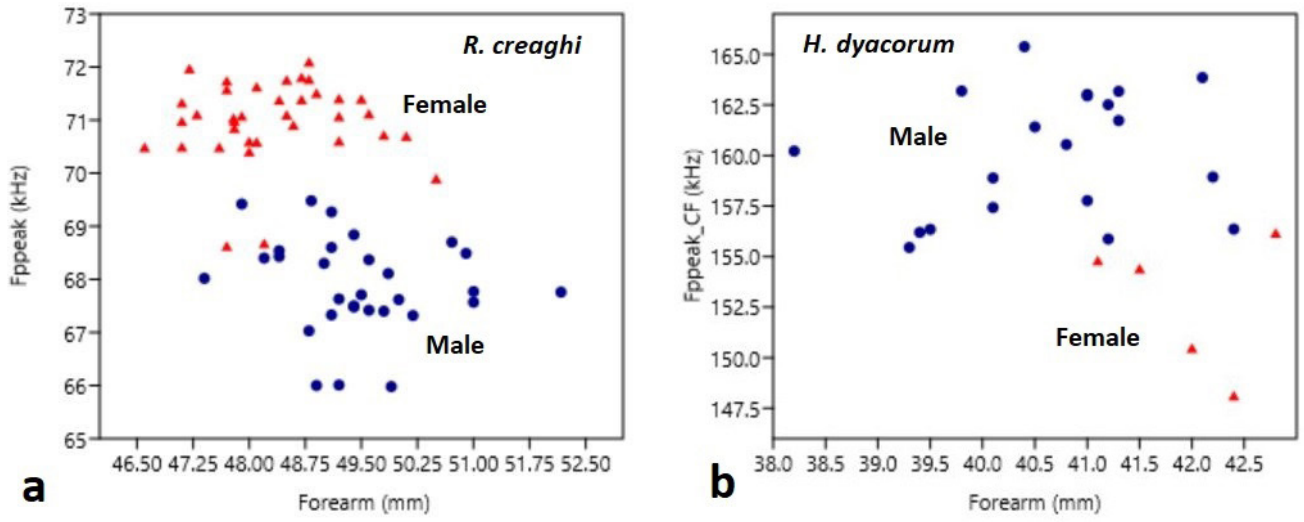

Fig. 4: Scatterplots showing the relationship between forearm length (mm) and peak frequency (kHz) for male (blue circle) and female (red triangle) individuals recorded in Gunung Mulu National Park, a) *Rhinolophus creaghi* and b) *Hipposideros dyacorum*.

Table 1 - Call harmonics (H) mean, standard deviation and range of *Rhinolophidae* and *Hipposideridae*. Number of calls examined for each harmonic in parenthesis.

Species	H1_Fppeak (kHz)	H3_Fppeak (kHz)	H4_Fppeak (kHz)
Rhinolophus borneensis	40.9 ± 2.2 34.9 - 47.1 (18)	122.5 ± 1.8 117.6 - 125.7 (39)	161.6 ± 5.8 142.5 - 166.4 (15)
Rhinolophus creaghi	35.0 ± 1.5 30.1 - 36.1 (24)	104.0 ± 3.2 96.0 - 108.1 (33)	139.78 ± 3.3 134.6 - 144.1 (29)
Rhinolophus acuminatus	45.9 ± 7.1 41.6 - 54.1 (3)	120.6 ± 14.3 104.4 - 131.4 (3)	172.0 ± 4.7 168.6 - 175.3 (2)
Rhinolophus philippinensis	16.8 ± 0.26 16.4 - 17.4 (17)	67.7 ± 1.0 69.4 - 69.4 (17)	101.3 ± 0.7 100.8 - 102.1 (3)
Rhinolophus luctus	57.81 (1)	77.0 ± 0.1 76.9 - 77.0 (2)	114.9 ± 0.6 114.5 - 115.4 (2)
Hipposideros bicolor	65.7 ± 1.6 62.5 – 67.0 (12)	188.2 ± 1.7 186.6 – 190.5 (8)	
Hipposideros dyacorum	81.4 ± 3.7 77.9 – 90.5 (15)	239.6 ± 5.3 233.5 – 246.0 (6)	
Hipposideros coxi	24.7 ± 1.0 23.57 – 25.66 (4)	76.7 (1)	100.8 ± 2.4 99.1 – 102.4 (2)
Hipposideros cervinus	58.9 ± 2.7 56.4 – 63.4 (5)	175.3 ± 3.0 169.1 – 180.0 (25)	
Hipposideros galeritus	56.4 ± 0.8 54.9 – 57.4 (18)	170.7 ± 1.7 166.0 – 172.5 (11)	
Hipposideros diadema	33.2 ± 0.1 33.2 – 33.3 (2)	101.6 ± 2.2 97.4 – 106.2 (18)	135.8 ± 2.4 131.5 – 139.1 (13)
Coelops robinsoni	95.8 (1)		

Table 2 - Measurements of echolocation call harmonics mean, standard deviation (top) and range (bottom) for species producing multi-harmonic pulses recorded in GMNP. In measurements of *M. spasma and N. tragata* pulses, Fppeak varied between harmonics in each pulse measured. Dominant harmonics are in bold and number of pulses that the harmonic was dominant is in parenthesis.

Species	Harmonic No.	Fppeak (kHz)	Fstart (kHz)	Fend (kHz)	No. of pulses
Emballonura alecto/monticola (Emerging from cave)	1	22.8 ± 0.4 22.4- 23.4	24.2 ± 0.4 23.6 - 24.6	18.9 ± 1.4 16.8 - 20.0	4
	3	66.3 ± 2.6 62.8 - 69.0	70.8 ± 0.8 70.0 - 71.8	56.2 ± 6.4 52.3 - 65.8	4
	4	88.2 ± 3.1 84.1 - 91.6	94.7 ± 0.7 94.1 - 95.5	80.5 ± 4.0 74.6 - 83.2	4
Megaderma spasma (Flying in small room)	1	37.6 ± 0·2 37.4 – 37.7	42.3 ± 0.4 42.0 – 42.5	31.50	2
	2 (1)	51.2	60.5 ± 2.8 58.5 – 62.5	47.3 ± 1.1 46.5 – 48.0	2
	3	70.5 ± 2.1 69.0 – 72.0	77.8 ± 0.4 77.5 – 78.0	64.5 ± 1.4 63.5 – 65.5	2
	4 (1)	89.9	102.5	83.0	1
Nycteris tragata (Flying in tent)	1	18.8 ± 1·5 16.3 – 21.0	27.6 ± 2·9 24.0 – 32.5	14.6 ± 0·6 14.0 – 15.5	7
	2	44.3 ± 2.0 42.0 – 47.8	51.6 ± 3·3 46.0 – 56.0	35.4 ± 3·5 32.0 – 42.0	7
	3 (2)	71.7 ± 5.6 62.9 – 80.9	80.6 ± 6.5 68.0 – 90.0	59.6 ± 4.0 54.0 – 68.0	12
	4 (10)	95.9 ± 6·6 81.1 – 103.7	111.9 ± 7.0 103.5 – 129.0	82.3 ± 6.5 73.0 – 93.5	13
	5 (1)	119.0 ± 7.4 104.8 – 128.9	143.4 ± 5.9 131.0 – 155.0	112.9 ± 6.9 102.0 – 126.0	12
Nycteris tragata (Release)	1	20.5 ± 0·9 19.5 – 21.1	27.2 ± 2·8 24.0 – 29.0	15.3 ± 1·2 14.0 – 16.0	2
	2 (1)	48.3 ± 6.1 42.0 – 56.7	54.9 ± 4.1 50.5 – 60.0	39.0 ± 6.2 34.0 – 48.0	3
	3 (2)	76.2 ± 6.2 69.1 – 87.0	81.5 ± 4.5 74.0 – 88.0	60.4 ± 2.4 57.0 – 63.5	6
	4 (4)	93.4 ± 7.6 75.1 – 99.0	109.8 ± 4.7 104.0 – 118.0	81.5 ± 5.8 71.0 – 88.0	7
	5	118.2 ± 7.8 109.4 – 127.4	140.9 ± 5.7 135.0 – 150.5	110.6 ± 6.1 105.0 – 121.0	6
Myotis horsfieldii (Flying in tent)	2	109.9 ± 9·4 101.5 – 123.1	148.5 ± 6.0 141.5 – 155.0	83.4 ± 6.4 74.00 – 88.5	4
Myotis horsfieldii (Release: semi-clutter - trail)	2	92.9	145.5	76.0	1
Myotis horsfieldii (Release: semi-clutter - stream)	2	107.5	156.5	86.0	1
Myotis horsfieldii (Release: open space)	2	111.1	135.0	105.5	1
Myotis muricola (Flying in tent)	2	118.5 ± 15·3 96.1 – 129.0	140.9 ± 19.4 114.6 – 159.1	101.8 ± 8·9 90.5 – 109.6	4
Myotis muricola (Release: semi-clutter)	2	109.6 ± 9·0 95.6 – 121.0	143.9 ± 12.4 122.5 – 159.6	101.1 ± 4.0 97.3 – 109.0	8
Myotis muricola (Release: open space)	2	114.7 ± 7.4 105.0 – 123.1	135.4 ± 8.6 126.5 – 145.0	105.6 ± 4.3 99.5 – 109.0	4
Myotis ridleyi (Flying in tent)	2	125.05	162.50	112.00	1

Table 2 - Continuation

Species	Harmonic No.	Fppeak (kHz)	Fstart (kHz)	Fend (kHz)	No. of pulses
Glischropus tylopus (Flying in tent)	2	106.5 ± 6.3 102.1 – 110.9	142.3 ± 20.2 128.0 – 156.5	92.8 ± 3.2 90.5 – 95.0	2
	3	130.6	144.0	129.5	1
Miniopterus australis (Flighing in tent)	2	114.3 ± 2.7 111.1 – 117.4	137.8 ± 7.6 128.2 – 146.4	110.0 ± 3.7 104.5 – 112.3	4
Miniopterus australis (Flying in a cave)	2	128.2 ± 3.2 125.9 – 130.5	149.6 ± 9.1 143.18 – 156.0	109.57 ± 1.3 108.64 – 110.5	2
Chaerephon plicatus (Flying in large room)	2	63.7 ± 1.2 62.9 – 64.6	82.0 ± 0.7 81.5 – 82.5	37.8 ± 6.0 33.5 – 42.0	2
	3	72.5 ± 0.7 72.0 – 73.0	89.8 ± 3.2 87.5 – 92.0	57.0 ± 4.2 54.0 – 60.0	2
Chaerephon plicatus (Release: open space - alternating call type A)	2	55.1 ± 10.7 42.3 – 71.3	68.0 ± 8.9 49.5 – 78.5	46.1 ± 4.1 38.5 – 51.3	8
Chaerephon plicatus (Release: open space - alternating call type B)	2	51.1 ± 5.7 44.2 – 56.9	65.8 ± 12.9 49.4 – 81.0	45.6 ± 4.4 42.3 – 52.0	4

Table 3: Discriminant Function Analysis classification results for all individuals of 31 species recorded in GNNP. *n* = number of call pulses per species. Rhac = *Rhinolophus acuminatus*, Rhbo = *R. borneensis*, Rhcr = *R. creaghi*, Rhlu = *R. luctus*, Rhph = *R. philippinensis*, Hibi = *Hipposideros bicolor*, Hice = *H. cervinus*, Hico = *H. coxi*, Hidi = *H. diadema*, Hidy = *H. dyacorum*, Higa = *H. galeritus*, Hicf.ku = *H.* cf. *kunzi*, Coro = *Coelops robinsoni,* Emsp = *Emballonura alecto/monticola,* Mesp = *M. spasma*, Nytr = *N. tragata*, Muae = *M. aenea*, Mupe = *M. peninsularis*, Muro = *M. rozendaali*, Musu = *M. suilla*, Keha = *K. hardwickii*, Kein = *K. intermedia*, Kemi = *K. minuta*, Kepa.L = *K. papillosa* (large form), Kepa.S = *K. papillosa* (small form), Kepe = *K. pellucida*, Myho = *M. horsfieldi*i, Mymu = *M. muricola*, Myri = *M. ridleyi*, Glty= *G. tylophus*, Miau = *M. australis*, Chpl = *C. plicatus*.

	True Species																															
Classified as:	Rhac	Rhbo	Rhcr	Rhlu	Rhph	Hibi	Hice	Hico	Hidi	Hidy	Higa	Hicf.ku	Coro	Emsp	Mesp	Nytr	Muae	Mupe	Muro	Musu	Keha	Kein	Kemi	Kepa.L	Kepa.S	Kepe	Myho	Mymu	Myri	Glty	Miau	Chpl	Overall
Rhac	3	21	3	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	
Rhbo	3	44	6	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	
Rhcr	0	4	145	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	
Rhlu	0	0	0	1	10	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	
Rhph	0	0	0	1	49	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	
Hibi	0	0	0	0	0	74	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	
Hice	0	0	0	0	0	0	84	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
Hico	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Hidi	0	1	1	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
Hidy	0	0	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Higa	0	0	0	0	0	0	9	0	0	0	54	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Hicf.ku	0	0	0	0	0	4	0	0	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Coro	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
Emsp	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
Mesp	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	
Nytr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
Muae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	
Mupe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	
Muro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	
Musu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	4	0	0	0	6	0	0	0	0	0	0	0	0	
Keha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	4	0	0	0	0	0	0	
Kein	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	3	1	0	0	0	0	0	0	
Kemi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	11	1	7	0	0	0	0	0	0	0	
Kepa.L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	15	2	0	0	0	0	0	0	0	
Kepa.S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	7	0	0	0	0	0	0	0	
Kepe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	1	0	11	0	0	0	0	0	0	
Myho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	
Mymu	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	5	0	1	6	0	
Myri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	0	2	0	
Glty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	3	0	3	0	0	
Miau	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	7	1	0	7	0	
Chpl	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	18	
Total *n*	6	70	155	2	59	78	93	23	32	45	60	4	5	4	2	20	2	7	2	8	12	4	14	25	20	16	9	17	2	4	17	22	839
n Correct	3	44	145	1	49	74	84	23	32	42	54	4	4	4	0	11	2	2	0	4	6	2	11	15	7	11	6	5	1	3	7	18	674
% Correct	50.0	62.9	93.5	50.0	83.1	94.9	90.3	100.0	100.0	93.3	90.0	100.0	80.0	100.0	0.0	55.0	100.0	28.6	0.0	50.0	50.0	50.0	78.6	60.0	35.0	68.8	66.7	29.4	50.0	75.0	41.2	81.8	80.3

Table 4 – Discriminant Function Analysis results for axis loadings, eigenvalues and percentage variation of call parameters for call groups and selected species.

Call Groups & Species	Loadings	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
All Calls	Fppeak	3.66	-2.36	1.34	0.43	-5.98
	Fstart	5.23	3.53	3.39	0.93	1.35
	Fend	2.54	-4.39	-0.87	0.71	1.82
	Duration	-1.89	-1.88	4.67	2.76	0.78
	IPI	-4.24	-0.15	2.66	25.84	-0.49
	Eigenvalue	87.45	14.15	6.66	0.94	
	Variance (%)	**78.68**	**12.73**	**6.00**	**0.84**	
FM-CF-FM Calls	Fppeak	1.42	-0.27	0.36	-0.16	
	Fstart	1.21	0.80	-1.03	2.75	
	Fend	1.20	2.73	-0.49	2.01	
	Duration	-0.28	-0.74	7.59	6.59	
	IPI	-0.36	15.12	28.93	7.79	
	Eigenvalue	142.40	0.17	0.03	0.00	
	Variance (%)	**99.86**	**0.12**	**0.02**	**0.00**	
CF-FM & QCF-MH Calls	Fppeak	2.20	1.42	-0.98	-4.53	0.57
	Fstart	2.39	0.02	-0.01	0.31	-0.08
	Fend	1.81	3.08	-1.94	0.85	1.25
	Duration	-0.07	0.47	1.00	0.02	0.44
	IPI	-0.35	-0.07	0.76	0.56	6.51
	Eigenvalue	171.37	2.57	1.35	0.32	
	Variance (%)	**97.47**	**1.46**	**0.77**	**0.18**	
FM-B, FM-MH & FM-QCF Calls	Fppeak	5.78	3.69	1.81	12.04	1.58
	Fstart	9.20	7.05	-7.32	-3.37	-0.44
	Fend	2.98	0.65	8.09	-1.15	0.86
	Duration	-0.48	0.77	0.04	-0.04	-0.26
	IPI	-8.66	9.36	0.00	-1.61	25.25
	Eigenvalue	39.79	5.41	1.72	0.24	
	Variance (%)	**84.72**	**11.51**	**3.65**	**0.51**	
***K. papillosa* (L), *K. papillosa* (S)**	Fppeak	5.08				
	Fstart	5.19				
	Fend	6.94				
	Duration	-0.07				
	IPI	-0.33				
***M. muricola, M. australis* (incl. 2nd harmonics)**	Fppeak	-0.22				
	Fstart	2.78				
	Fend	0.33				
	Duration	0.09				
	IPI	-2.25				
	H2_Fppeak	-2.79				
	H2_Fstart	4.75				
	H2_Fend	-0.46				

Table 5 - Discriminant Function Analysis classification results for FM-CF-FM (Rhinolophidae) calls recorded in GMNP. *n* = number of call pulses per species. Rhac = *Rhinolophus acuminatus*, Rhbo = *R. borneensis*, Rhcr = *R. creaghi*, Rhlu = *R. luctus*, Rhph = *R. philippinensis*.

	True Species					
Classified as:	Rhac	Rhbo	Rhcr	Rhlu	Rhph	Overall
Rhac	5	9	0	0	0	
Rhbo	1	61	0	0	0	
Rhcr	0	0	155	0	0	
Rhlu	0	0	0	2	0	
Rhph	0	0	0	0	59	
Total *n*	6	70	155	2	59	292
n Correct	5	61	155	2	59	282
% Correct	83.3	87.1	100.0	100.0	100.0	96.6

Table 6 - Discriminant Function Analysis classification results for CF-FM and QCF-MH (Hipposideridae and Emballonuridae) calls recorded in GMNP. *n* = number of call pulses per species. Hibi = *Hipposideros bicolor*, Hice = *H. cervinus*, Hico = *H. coxi*, Hidi = *H. diadema*, Hidy = *H. dyacorum*, Higa = *H. galeritus*, Hicf.ku = *H*. cf. *kunzi*, Coro = *Coelops robinsoni*, Emsp = *Emballonura alecto/monticola.*

	True Species									
Classified as:	Hibi	Hice	Hico	Hidi	Hidy	Higa	Hicf.ku	Coro	Emsp	Overall
Hibi	78	0	0	0	0	0	0	0	0	
Hice	0	84	0	0	0	3	0	0	0	
Hico	0	0	23	0	0	0	0	0	0	
Hidi	0	0	0	32	0	0	0	0	0	
Hidy	0	0	0	0	42	0	0	0	0	
Higa	0	9	0	0	0	57	0	0	0	
Hicf.ku	0	0	0	0	3	0	4	0	0	
Coro	0	0	0	0	0	0	0	5	0	
Emsp	0	0	0	0	0	0	0	0	4	
Total *n*	78	93	23	32	45	60	4	5	4	344
n Correct	78	84	23	32	42	57	4	5	4	329
% Correct	100.0	90.3	100.0	100.0	93.3	95.0	100.0	100.0	100.0	95.6

Table 7 – Discriminant Function Analysis classification results for FM-B, FM-MH and FM-QCF calls recorded in GMNP. *n* = number of call pulses per species. Mesp = *M. spasma*, Nytr = *N. tragata*, Muae = *M. aenea*, Mupe = *M. peninsularis*, Muro = *M. rozendaali*, Musu = *M. suilla*, Keha = *K. hardwickii*, Kein = *K. intermedia*, Kemi = *K. minuta*, Kepa.L = *K. papillosa* (large form), Kepa.S = *K. papillosa* (small form), Kepe = *K. pellucida*, Myho = *M. horsfield*ii, Mymu = *M. muricola*, Myri = *M. ridleyi*, Glty= *G. tylophus*, Miau = *M. australis*, Chpl = *C. plicatus*.

	True Species																		
Classified as:	Mesp	Nytr	Muae	Mupe	Muro	Musu	Keha	Kein	Kemi	Kepa.L	Kepa.S	Kepe	Myho	Mymu	Myri	Glty	Miau	Chpl	Overall
Mesp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Nytr	0	16	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
Muae	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	
Mupe	0	1	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	
Muro	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	
Musu	0	1	0	1	0	5	0	0	0	2	0	0	0	0	0	0	0	0	
Keha	0	0	0	0	0	0	6	0	0	0	0	4	0	0	0	0	0	0	
Kein	0	0	0	0	0	0	0	2	1	0	3	1	0	0	0	0	0	0	
Kemi	0	0	0	0	0	0	0	1	12	1	6	0	0	0	0	0	0	0	
Kepa.L	0	0	0	0	0	1	0	0	0	19	2	0	0	0	0	0	0	0	
Kepa.S	0	0	0	0	0	0	0	1	1	0	9	0	0	0	0	0	0	0	
Kepe	0	0	0	0	0	0	6	0	0	1	0	11	0	0	0	0	0	0	
Myho	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	
Mymu	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	1	5	1	
Myri	0	1	0	1	0	0	0	0	0	0	0	0	1	2	2	0	0	0	
Glty	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	1	0	
Miau	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	10	0	
Chpl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	
Total *n*	2	20	2	7	2	8	12	4	14	25	20	16	9	17	2	4	17	22	203
n Correct	0	16	2	5	1	5	6	2	12	19	9	11	6	8	2	3	10	21	138
% Correct	0.0	80.0	100.0	71.4	50.0	62.5	50.0	50.0	85.7	76.0	45.0	68.8	66.7	47.1	100.0	75.0	58.8	95.5	68.0
Kepa.L										24	2								
Kepa.s										1	18								
Total *n*										25	20								45
n Correct										24	18								42
% Correct										96.0	90.0								93.3
Incl. 2nd Harmonics																			
Myho													7	0			0	0	
Mymu													0	16			0	0	
Miau													0	0			6	0	
Chpl													0	0			0	14	
Total *n*													7	16			6	14	43
n Correct													7	16			6	14	43
% Correct													100.0	100.0			100.0	100.0	100.0

Table S8 – Call situation comparison results for the same individuals recorded either as stationary (Rhinolophidae and Hipposideridae) or flying in an enclosure (flight tent or room, all remaining species except *C. plicatus*) and release (all species). In release calls for *C. plicatus*, alternating call pulses (Calls A and B) produced in open space were compared. Fppeak = peak frequency, Fstart = start frequency, Fend = terminal frequency, PD = pulse duration, IPI = interval between pulses. T Test for paired samples was conducted on call parameters where p value of Shapiro-Wilk's test was >0.05. Wilcoxan test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

Species	N	Call Parameter	Normality Test				T Test (paired Samples)				Wilcoxan Test				p value	Sig. level
			Shapiro-Wilk W Stationary	p(normal) Stationary	Shapiro-Wilk W Release	p(normal) Release	Mean Stat.	Mean Rel.	Mean diff	t value	Median Stat.	Median Release	w	Normal appr. z:		
R. borneensis	22	Fppeak	0.97	0.66	0.97	0.68	81.72	80.60	1.65	8.89					**< 0.001**	***
		PD	0.90	**0.03**	0.97	0.71					55.17	42.54	198.00	2.87	**0.004**	**
		IPI	0.99	0.99	0.86	**0.01**					114.02	72.30	243.00	3.78	**< 0.001**	***
R.creaghi	22	Fppeak	0.94	0.18	0.95	0.29	68.87	67.54	1.33	6.08					**< 0.001**	***
		PD	0.96	0.42	0.90	**0.03**					57.52	51.97	213.00	2.81	**0.005**	**
		IPI	0.96	0.48	0.94	0.18	132.80	83.77	49.03	4.84					**< 0.001**	***
R. acuminatus	3	Fppeak	0.80	0.10	0.87	0.30	85.07	83.20	1.87	5.59					**0.031**	*
		PD	0.99	0.84	1.00	0.95	35.13	45.92	10.79	34.81					**< 0.001**	***
		IPI	0.91	0.42	0.87	0.29	39.76	74.89	35.13	-3.02					0.094	ns
R. philippensis	22	Fppeak	0.97	0.71	0.94	0.25	33.85	33.09	0.75	12.31					**< 0.001**	***
		PD	0.95	0.36	0.97	0.65	55.14	58.45	3.32	-1.85					0.079	ns
		IPI	0.98	0.91	0.90	**0.03**					99.48	108.89	163.00	1.65	0.099	ns
H. bicolor	22	Fppeak	0.77	**0.00**	0.94	**0.03**					132.61	132.00	196.00	2.26	**0.024**	*
		Fppeak_CF	0.92	**0.01**	0.94	**0.03**					132.89	132.19	184.00	2.38	**0.017**	*
		Fend	0.98	0.77	0.97	0.52	110.62	109.87	0.74	0.77					0.450	ns
		PD	0.94	**0.04**	0.98	0.80					6.97	7.13	121.50	1.07	0.286	ns
		IPI	0.96	0.21	0.96	0.16	17.19	15.27	1.92	1.74					0.097	ns
H. dyacorum	17	Fppeak	0.93	0.26	0.96	0.68	142.99	147.54	4.55	-1.50					0.154	ns
		Fppeak_CF	0.93	0.26	0.96	0.63	158.78	159.18	0.40	-0.93					0.364	ns
		Fend	0.99	1.00	0.89	**0.05**					128.14	126.67	95.50	0.90	0.368	ns
		PD	0.89	0.05	0.93	0.20	5.03	5.28	0.25	-1.42					0.174	ns
		IPI	0.84	**0.01**	0.89	**0.04**					15.23	13.55	121.00	2.11	**0.035**	*
H. coxi	10	Fppeak	0.83	**0.03**	0.97	0.88					50.15	50.60	33.50	1.30	0.192	ns
		Fppeak_CF	0.83	**0.03**	0.97	0.88					50.15	50.60	33.50	1.30	0.192	ns
		Fend	0.87	0.09	0.94	0.60	42.67	42.92	0.24	-0.47					0.650	ns
		PD	0.79	**0.01**	0.96	0.74					6.41	6.41	28.00	0.05	0.959	ns
		IPI	0.98	0.95	0.82	**0.02**					22.63	21.81	24.00	0.18	0.859	ns

Table 8 – Continuation: Fppeak = peak frequency, Fstart = start frequency, Fend = terminal frequency, PD = pulse duration, IPI = interval between pulses. T Test for paired samples was conducted on call parameters where p value of Shapiro-Wilk's test was >0.05. Wilcoxan test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

Species	N	Call Parameter	Normality Test				T Test (paired Samples)				Wilcoxan Test				p value	Sig. level
			Shapiro-Wilk W St.	p(normal) St.	Shapiro-Wilk W Rel.	p(normal) Rel.	Mean St.	Mean Rel	Mean diff	t value	Median St.	Median Rel.	w	Normal appr. z:		
H. cervinus	22	Fppeak	0.97	0.69	0.96	0.44	117.81	117.13	0.69	4.67					**< 0.001**	***
		Fppeak_CF	0.97	0.69	0.96	0.44	117.81	117.13	0.69	4.67					**< 0.001**	***
		Fend	0.94	0.24	0.97	0.63	102.67	101.73	0.93	1.46					0.159	ns
		PD	0.89	**0.02**	0.96	0.43					5.09	5.34	150.50	1.70	0.089	ns
		IPI	0.83	**0.00**	0.95	0.34					22.75	18.97	191.00	2.62	**0.009**	**
H. galeritus	21	Fppeak	0.71	**0.00**	0.67	0.00					113.07	111.57	206.00	3.15	**0.002**	**
		Fppeak_CF	0.92	0.10	0.93	0.13	112.85	112.20	0.65	5.09					**< 0.001**	***
		Fend	0.98	0.92	0.84	**0.00**					94.78	93.18	123.50	0.69	0.490	ns
		PD	0.97	0.79	0.96	0.58	5.98	5.85	0.13	0.52					0.612	ns
		IPI	0.83	**0.00**	0.97	0.83					22.53	21.39	129.50	0.91	0.360	ns
H. diadema	11	Fppeak	0.93	0.37	0.93	0.39	68.26	66.97	1.29	5.39					**< 0.001**	***
		Fppeak_CF	0.93	0.37	0.93	0.39	68.26	66.97	1.29	5.39					**< 0.001**	***
		Fend	0.96	0.72	0.83	**0.03**					58.41	56.36	31.50	0.41	0.683	ns
		PD	0.91	0.26	0.90	0.19	10.16	11.07	0.91	-1.05					0.320	ns
		IPI	0.98	0.94	0.91	0.21	29.43	41.81	12.38	-2.37					**0.039**	*
K. minuta	4	Fppeak	0.87	0.30	0.96	0.78	121.89	130.50	8.61	-5.54					0.012	*
		Fstart	0.85	0.22	0.79	0.08	162.75	153.28	9.48	1.22					0.308	ns
		Fend	0.82	0.14	0.86	0.26	98.72	101.00	2.29	-0.78					0.494	ns
		PD	0.91	0.46	1.00	0.98	1.98	1.84	0.14	1.26					0.297	ns
		IPI	0.98	0.91	0.99	0.96	14.02	14.16	0.14	-0.27					0.808	ns
K. papillosa	12	Fppeak	0.94	0.49	0.90	0.17	122.85	119.62	3.24	0.57					0.578	ns
		Fstart	0.72	0.00	0.86	**0.04**					162.87	163.75	24.00	0.18	0.859	ns
		Fend	0.85	**0.04**	0.88	0.08					81.55	76.50	42.50	0.85	0.398	ns
		PD	0.93	0.40	0.90	0.16	2.22	2.18	0.03	0.33					0.745	ns
		IPI	0.95	0.65	0.83	**0.02**					15.00	14.58	50.00	0.86	0.388	ns

Table 8 – Continuation: Fppeak = peak frequency, Fstart = start frequency, Fend = terminal frequency, PD = pulse duration, IPI = interval between pulses. T Test for paired samples was conducted on call parameters where p value of Shapiro-Wilk's test was >0.05. Wilcoxan test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

Species	N	Call Parameter	Normality Test				T Test (paired samples)				Wilcoxan Test				p value	Sig. level
			Shapiro-Wilk W Flight Tent	p(normal) Flight Tent	Shapiro-Wilk W Release	p(normal) Release	Mean FT	Mean Rel.	Mean diff	t value	Median FT	Median Release	w	Normal appr. z:		
K. minuta	4	Fppeak	0.87	0.30	0.96	0.78	121.89	130.50	8.61	-5.54					0.012	*
		Fstart	0.85	0.22	0.79	0.08	162.75	153.28	9.48	1.22					0.308	ns
		Fend	0.82	0.14	0.86	0.26	98.72	101.00	2.29	-0.78					0.494	ns
		PD	0.91	0.46	1.00	0.98	1.98	1.84	0.14	1.26					0.297	ns
		IPI	0.98	0.91	0.99	0.96	14.02	14.16	0.14	-0.27					0.808	ns
K. papillosa	12	Fppeak	0.94	0.49	0.90	0.17	122.85	119.62	3.24	0.57					0.578	ns
		Fstart	0.72	0.00	0.86	**0.04**					162.87	163.75	24.00	0.18	0.859	ns
		Fend	0.85	**0.04**	0.88	0.08					81.55	76.50	42.50	0.85	0.398	ns
		PD	0.93	0.40	0.90	0.16	2.22	2.18	0.03	0.33					0.745	ns
		IPI	0.95	0.65	0.83	**0.02**					15.00	14.58	50.00	0.86	0.388	ns
K. pellucida	5	Fppeak	0.93	0.63	0.90	0.39	137.69	121.16	16.53	2.31					0.082	ns
		Fend	0.83	0.14	0.89	0.36	64.30	84.60	20.30	-2.47					0.069	ns
		PD	0.77	**0.05**	0.91	0.48					2.42	2.01	0.28	1.43	0.180	ns
		IPI	0.88	0.32	0.86	0.24	12.91	12.89	0.02	0.02					0.985	ns
M. peninsularis	4	Fppeak	0.87	0.31	0.97	0.85	101.19	99.65	1.55	0.12					0.913	ns
		Fstart	0.95	0.69	0.98	0.92	159.16	135.95	23.21	3.04					0.056	ns
		Fend	0.82	0.15	0.91	0.47	52.89	60.00	7.11	-1.81					0.168	ns
		PD	0.95	0.73	0.98	0.88	2.20	1.69	0.51	1.82					0.166	ns
		IPI	0.94	0.68	0.92	0.54	20.21	18.62	1.59	1.53					0.224	ns
M. muricola	7	Fppeak	0.87	0.19	0.98	0.93	65.75	55.49	10.26	2.22					**0.016**	*
		Fstart	0.95	0.73	0.86	0.16	109.82	85.07	24.75	2.77					**0.032**	*
		Fend	0.94	0.62	0.92	0.46	47.84	49.86	2.02	-2.01					0.091	ns
		PD	0.91	0.38	0.92	0.46	3.17	3.94	0.77	-1.58					0.164	ns
		IPI	0.98	0.94	0.96	0.83	66.63	90.24	23.62	-2.24					0.067	ns

Table 8 – **Continuation:** Fppeak = peak frequency, Fstart = start frequency, Fend = terminal frequency, PD = pulse duration, IPI = interval between pulses. T Test for paired samples was conducted on call parameters where p value of Shapiro-Wilk's test was >0.05. Wilcoxan test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

Species	N	Call Parameter	Normality Test				T Test (paired samples)				Wilcoxan Test				p value	Sig. level
			Shapiro-Wilk W Flight Tent	p(normal) Flight Tent	Shapiro-Wilk W Release	p(normal) Release	Mean FT	Mean Rel	Mean diff	t value	Median FT	Median Rel	w	Normal appr. z:		
N. tragata	7	Fppeak	0.81	**0.05**	0.85	0.13					95.89	92.90	21.00	1.18	0.237	ns
		Fstart	0.92	0.45	0.86	0.15	144.71	136.93	7.79	1.70					0.141	ns
		Fend	0.97	0.88	0.73	**0.01**					61.00	60.50	14.00	0.00	1.000	ns
		PD	0.94	0.62	0.84	0.09	1.09	1.06	0.03	0.25					0.808	ns
		IPI	0.66	**0.00**	0.90	0.31					10.51	15.42	19.00	0.85	0.398	ns
			Shapiro-Wilk W Release Call A	p(normal) Rel. Call A	Shapiro-Wilk W Rel. Call B	p(normal) Rel. Call B	Mean Rel. A	Mean Rel. B	Mean diff	t value					p value	Sig. level
C. plicatus	8	Fppeak	0.87	0.14	0.88	0.21	26.49	24.27	2.22	4.76					**0.002**	**
		Fstart	0.92	0.47	0.90	0.27	41.69	34.73	6.96	4.79					**0.002**	**
		Fend	0.95	0.71	0.96	0.83	21.89	20.79	1.11	2.95					**0.021**	*
		PD	0.95	0.71	0.93	0.49	13.48	13.92	0.44	-0.83					0.435	ns
		IPI	0.84	0.08	0.85	0.11	240.55	158.46	82.09	4.33					**0.003**	**

Table 9 – Results of ANOVA, Kruskal-Wallis and Tukey Pairwise tests for comparison of call parameters of different individuals of *Miniopterus australis* recorded in different flight situations: flying in a flight tent, flying in a cave and after emerging from a cave. Fppeak = peak frequency, Fppeak_QCF = peak frequency of the quasi-constant frequency component, Fstart = start frequency, Fend = terminal frequency, PD = pulse duration, IPI = interval between pulses. ANOVA was conducted on call parameters where p value of Shapiro-Wilk's test was >0.05. Kruskal-Wallis test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

Unmatched Samples		Normality						ANOVA								
		Flight Tent		In Cave		Emergence		Between groups			Within groups					
		Shapiro-Wilk W	p(norm)	Shapiro-Wilk W	p(norm)	Shapiro-Wilk W	p(norm)	Sum of sqrs	df	Mean square	Sum of sqrs	df	Mean square	F	p(same)	Sig. level
	Fppeak	0.89	0.40	0.96	0.64	0.87	0.10	195.55	2.00	97.78	98.80	14.00	7.06	13.86	**< 0.001**	***
	Fppeak-QCF	0.80	0.10	0.88	0.31	0.87	0.10	62.64	2.00	31.32	22.12	14.00	1.58	19.82	**< 0.001**	***
	Fstart	0.83	0.16	0.92	0.46	0.89	0.18	1806.32	2.00	903.16	3856.83	14.00	275.49	3.28	0.068	ns
	Fend	0.89	0.37	0.78	0.06	0.95	0.64	2.73	2.00	1.36	18.72	14.00	1.34	1.02	0.386	ns
								Kruskal-Wallis test for equal medians								
								Median (FT)	Median (Cave)	Median (Emerg)	H (chi2):	Hc (tie corrected):			p(same)	
	PD	0.77	0.06	0.79	0.10	0.82	**0.02**	4.09	1.78	3.89	2.57	2.60			0.272	ns
	IPI	0.80	0.10	1.00	0.95	0.83	**0.03**	38.39	32.04	56.40	2.79	2.81			0.246	ns

M. australis

Tukey Pairwise	Fppeak	Fppeak. Rel	Fppeak. CE	Fppeak-QCF (FT)	Fppeak-QCF (Cave)	Fppeak-QCF (Emerg.)
Fppeak (FT)		0.1610	**< 0.001**			
Fppeak (Cave)	2.761		0.0791			
Fppeak (Emerg.)	7.287	3.3450				
Fppeak-QCF (FT)					0.0549	**< 0.001**
Fppeak-QCF (Cave)				3.6300		0.0514
Fppeak-QCF (Emerg.)				8.7810	3.6800	

Table 10 – Results of T tests and Mann-Whitney U test for differences between male and female forearm length (mm) and peak frequency (kHz) for nine species of rhinolophid and hipposiderid bats. Fppeak was measured from the CF component of the pulse for all individuals. T Test was conducted on call parameters where p value of Shapiro-Wilk's test was >0.05. Mann-Whitney U test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

Species	Forearm/ Fppeak	Normality Test				T Test				Mann-Whitney U Test					
		Shapiro-Wilk W Female	p(normal) Female	Shapiro-Wilk W Male	p(normal) Male	Mean Female	Mean Male	Mean diff	t value	Mean Rank Female	Mean Rank Male	Mann-Whitn U:	z :	p value	Sig. level
R. borneensis	Forearm	0.97	0.60	0.86	**0.03**					13.29	5.21	96.50	1.73	0.084	ns
Male: 13, Female: 23	Fppeak	0.97	0.67	0.94	0.51	81.71	81.52	0.18	-0.45					0.658	ns
R. creaghi	Forearm	0.98	0.67	0.96	0.22	48.33	49.35	1.02	-3.96					**< 0.001**	***
Male: 31, Female:36	Fppeak	0.87	**0.00**	0.95	0.15					26.42	7.58	12.00	6.86	**< 0.001**	***
R. philippinensis	Forearm	0.97	0.93	0.96	0.63	52.20	51.47	0.74	1.89					0.070	ns
Male: 17 , Female: 11	Fppeak	0.95	0.70	0.95	0.42	33.66	33.84	0.18	-0.99					0.332	ns
H. bicolor	Forearm	0.96	0.62	0.99	0.99	46.44	46.07	0.37	1.22					0.231	ns
Male: 16, Female: 16	Fppeak	0.94	0.40	0.89	0.07	132.84	132.68	0.16	0.28					0.778	ns
H. dyacorum	Forearm	0.98	0.93	0.97	0.71	41.96	40.64	1.32	2.62					**0.015**	*
Male: 20, Female: 5	Fppeak	0.90	0.43	0.93	0.13	152.80	160.06	7.26	-4.58					**< 0.001**	***
H. coxi	Forearm	0.99	0.96	0.95	0.71	53.10	51.57	1.53	2.39					**0.036**	*
Male: 9, Female: 4	Fppeak	0.93	0.59	0.85	0.08	49.42	49.23	0.19	0.16					0.877	ns
H. cervinus	Forearm	0.96	0.60	0.98	0.75	47.74	47.66	0.09	0.25					0.800	ns
Male: 30, Female: 18	Fppeak	0.90	0.07	0.98	0.69	117.12	117.68	0.56	-0.96					0.342	ns
H. galeritus	Forearm	0.85	**0.04**	0.95	0.35					7.63	10.37	87.00	1.76	0.079	ns
Male: 23, Female: 12	Fppeak	0.93	0.38	0.91	**0.04**					4.63	13.37	84.00	1.86	0.063	ns
H. diadema	Forearm	0.97	0.85	0.86	0.27	81.75	81.56	0.19	0.13					0.897	ns
Male: 5, Female: 15	Fppeak	0.94	0.36	0.95	0.69	67.70	66.96	0.73	1.14					0.267	ns

Table 11 – Results of T test and Mann-Whitney U test for comparison of peak frequency (kHz) of individuals of the same species recorded in different localities, i.e. Gunung Mulu National Park (GMNP), Bako National Park (BNP) and Wind Cave Nature Reserve (WCNR). Fppeak was measured from the CF component of the pulse for all individuals. T Test was conducted on data where p value of Shapiro-Wilk's test was >0.05. Mann-Whitney U test was conducted on call parameters where p value of Shapiro-Wilk's test was <0.05. Significant results are in bold. Levels of significance are: * p <0.05, ** p <0.01 and *** p < 0.001.

	Individuals		**GMNP**		**BNP/WCNR**		**T Test**				**Mann-Whitney U Test**					
Species	**GMNP**	**BNP/ WCNR**	**Shapiro-Wilk W**	**p(normal)**	**Shapiro-Wilk W**	**p(normal)**	**Mean Mulu**	**Mean Bako/ WCNR**	**Mean diff**	**t value**	**Mean Rank Female**	**Mean Rank Male**	**Mann-Whitn U :**	**z :**	**p value**	**Sig. Level**
R. borneensis	40	6	0.97	0.66	0.88	0.27	81.61	81.84	0.23	-0.43					0.669	ns
R. luctus	2	3	1.00	1.00	0.83	0.18	38.35	38.82	0.48	-2.75					0.070	ns
H. cervinus	51	32	0.98	0.68	0.95	0.15	117.39	124.16	6.78	16.02					**< 0.001**	***
H. galeritus	39	21	0.92	0.10	0.96	0.61	112.46	112.23	0.23	0.49					0.626	ns
H. bicolor	39	4	0.92	**0.01**	0.69	**0.01**					21.00	1.00	33.00	-1.86	0.062	ns
H. coxi	13	5	0.83	**0.03**	0.90	0.43					8.50	1.00	3.00	-2.86	**0.004**	**
H. dyacorum	28	6	0.93	0.26	0.83	0.10	158.21	153.53	4.68	2.32					**0.027**	*
H. dyacorum (female only)	5	5	0.98	0.93	0.83	0.10	152.94	152.80	0.14	0.06					0.957	ns