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WING MORPHOLOGY AND ECOLOCATION CALLS OF *Taphozous melanopogon*, Temminck 1841 (Chiroptera: Emballonuridae) FROM CHAE-DAW-YAR CAVE

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Abstract

The wing morphology of black-bearded tomb bat, *Taphozous melanopogon* (Chiroptera: Emballonuridae) collected from the Chaedawyar Monastery cave, Madaya Township. The study of wing morphology, echolocation frequency of *T. melanopogon* analyzed during June 2018 to February 2019 involved 20 males and 20 females of *T. melanopogon*. The aim of this study was to examine whether wing morphology of bat have relationship with feeding habits. The wing parameters were measured onto one centimeter square graph paper in the field. Evaluation was focused on three major parameters; wing loading (WL), aspect ratio (A) and wing tip shape index (I) between males and females by using t-test. The values of wing loading (t = 0.881, df = 38, p = 0.219), aspect ratio (t = -196, df = 38, p = 0.478) and wing tip shape index (t =0 .843, df = 38, p = 0.072) were calculated. Echolocation frequency of *T. melanopogon* revealed that the peak frequency was 29.85 kHz. The study results concluded that *T melanopogon* wing morphology were not significant differences in nonreproductive female and male on intraspecific.

Keywords: wing morphology, echolocation calls, chaedawyar cave, Madaya Township

Introduction

In ecomorphological analysis, one seeks to establish the nature and strength of the relationship between morphology and ecology. The morphology of bats relates to their ecology, with special attending to the structure of the feeding apparatus, particularly the morphology of the wing in relation to flight performance. In bat ecomorphology, the feeding and flight apparatus have been the subjects of much study (Swartz *et al*., 2003). The food types of bats exploit a wider range than any other mammalian order.

Bats have wings of different shape and sizes. The differences are largely a reflection of the foraging strategy of the bat-where they feed, how they feed, and what they feed on. There are two main ways in which wings can vary. First, wing area can be large or small relative to the size of the bat and second, wings can be short and broad or long and narrow. The different structures of wing shape are also important the relative lengths and areas of the arm-and hand wing vary considerably. The shape of wing tip may be broad and rounded or narrow and pointed. All of these measurements were regarded as a bat's flight style and they can be related to its foraging strategy (Altringham, 1996).

The flight behavior and feeding niches of bats can be known by measuring the wing morphology. Generally, three factors of bats characterized are (i) high wing loading, high aspect ratio, and high wingtip shape indices fly fast in open area, (ii) high wing loading, average aspect ratios and average wingtip shape indices fly in and around the edges of vegetation in background-cluttered space, and (iii) low wing loading, average or low aspect ratios and pointed wing tip shape indices fly in highly-clutter space (Norberg and Rayner, 1987). Wing morphology is really important in shaping the flight style eg: aerial - hawking, trawling, gleaning or perch hunting. Most insectivorous bats catch their prey in flight, therefore flight style and wing morphology are very important in prey selection. Some morphological characteristics can be used to quantify diets to

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some degree, other external variables are also important in determining the diets of insectivorous bats eg: season, local insect community composition or geographic range (Moosan *et al*., 2012).

Wing characteristics which were measured body weight, forearm length showed the strongest relationship with hard insects followed by longest cranial length. The content of soft insects in bat diets was negatively related to body weight, forearm length and longest cranial length (Weterings & Umponstria, 2014).

In insectivorous bats, echolocation call structure and wing morphology is a primary determinant of foraging strategy (Norberg and Rayner 1987). The echolocation calls of microchiropteran bats have been categorized as constant frequency (CF: single tones which remain at one frequency for a time) or frequency modulated (FM: sweeping up or down in frequency). Calls can be made up of one or more of these components, and are consequently described as FM calls, CF/FM calls (with a CF components followed by an FM component (Jennings *et al*. 2004). Emballonurid bats foraging in edge space near vegetation and over water used higher frequencies, shorter call durations and shorter pulse intervals compared with species mostly hunting in open, uncluttered habitats (Jung *et al*. 2007).

Emballonurid bats produce shallow-modulated and multi-harmonic echolocation calls with most energy concentrated in the second harmonic. Although overall call structure is rather similar within the family, there are species-specific differences in call parameters, namely peak frequency, call duration, pulse interval, direction of call modulation, and presence or absence of short, frequency-modulated (FM) components. Echolocation call libraries are frequently developed over large geographic areas. Species that passes similar calls over broad geographic scales may however have allopatric distributions and hence may be identifiable from their echolocation calls if geographic range can be predicted accurately (Hughes *et al*. 2010).

In Upper Myanmar, there has been few research conducted on ecomorphology of some insectivorous bats. Nyo Nyo Tun (2007) worked on ecomorphology of five rhinolophids bats, three hipposiderids bats and one vespertilionid species. *Taphozous melanopogon* does not include in her study. The ecomorphology need to be studied as feeding ecology and flight performance was related. The aim of this study was to examine whether wing morphology of bat have relationship with feeding and foraging habitat. It is expected that wing shape will reflect the feeding habitat and feeding habit. Therefore, the present study has been undertaken with the following objectives:

- to assess the ecomorphology of *Taphozous melanopogon* from the study area
- to analyze the relationship between wing morphology of males and females by using multivariate statistical analysis
- to analyze the echolocation calls of *T melanopogon* in the study area

Materials and Methods

Study site

The study was conducted at Maha-bawdi-chaedawyar monastery cave (22˚10″45.481″N, 096˚15 ' 17.770″E) in the vicinity of Taungpulu village, Madaya Township, Mandalay. The colony resides in a limestone cave in the vicinity of the monastery. The cave is surrounded by a thick vegetations bamboo grove and woody plants (such as, Thityar, Ingyin, Dahat, Yinkhat etc.). Moreover, bananas plantations, mangoes trees, betel leaves, guava orchards and cultivated plots surround the adjacent areas (Fig 1). The study was carried out from June 2018 to February 2019.

Measurements and analysis of wing morphology

Bats were captured by hand nets inside the cave. Wing measurements were taken on alive and anaesthetized adult males and non-pregnant females. Body mass (M) was determined using a spring balance, Pesola (600 g) and forearm length was measured using digital calipers in accuracy 0.01 mm. The analysis of wing morphology followed after (Norberg and Rayner, 1987).

Body mass (M), was taken fresh specimens from which wing dimensions were also measured. Wingspan, (B), is the distance between the wingtip of a bat with wing extended so that the leading edge is straight. Wing area, (S), is the combined area of the two wings, the entire tail membrane and the portion of the body between the wings. Aspect ratio, (AR), calculated is the square of wing span divided by wing area, $A = B^2/S$ whereas, Wing loading, (WL), is mass (M) times gravitational acceleration ($g = 9.81$ m/ s^2) divided by wing area, $WL = Mg / S$. Tip length ratio, (Tl), is calculated the ratio of the length of the hand wing, L_{hw}, to the length of the arm wing, L_{aw}. $Tl = L_{hw}/L_{aw}$ and the tip area ratio, (Ts), is the ratio between the hand wing area (chiropatagium) S_{hw} to the arm wing area (plagiopatagium plus propatagium) S_{aw}. $Ts = S_{hw}/S_{aw}$. Tip shape index, (I), was evaluated as $I = Ts / Tl – Ts$ (Fig 2).

Wing tracing

In tracing the wing of *Taphozous melanopogon*, first each specimen was placed onto one centimeter square graph paper with the dorsal up, then the left wing the fully stretch to get a maximum span and fully stretched of the wing membrane. The uropatagium was also fully stretched. Then, the wing was carefully traced along the edges including one half of the head and the uropatagium.

Recording of echolocation calls

Echolocation calls were recorded for bats using an ultrasound detector (D1000X, Pettersson Electronic AB, Uppsala, Sweden) at a distance about 1 m the bat flew freely in dark after released from the cave entrance. Time-expanded calls were digitized to a sampling rate of 44.1 kHz with 16 bits precision and analyzed using the software Batsound (version 4.2.1). Start-frequency (Start-F, kHz) and end frequency (End-F, kHz) of each harmonic, pulse duration (PD, ms); DF was measured from power spectra, Start-F and End-F from spectrograms, and PD and IPI from oscillograms following Zhang *et al*. (2007).

Statistical analysis

The student t-test was used to analyze the difference ecomorphology of bat between males and females. Results were considered significant at $P < 0.05$. The Statistical Analysis for Social Sciences SPSS (version 22) was used for analysis.

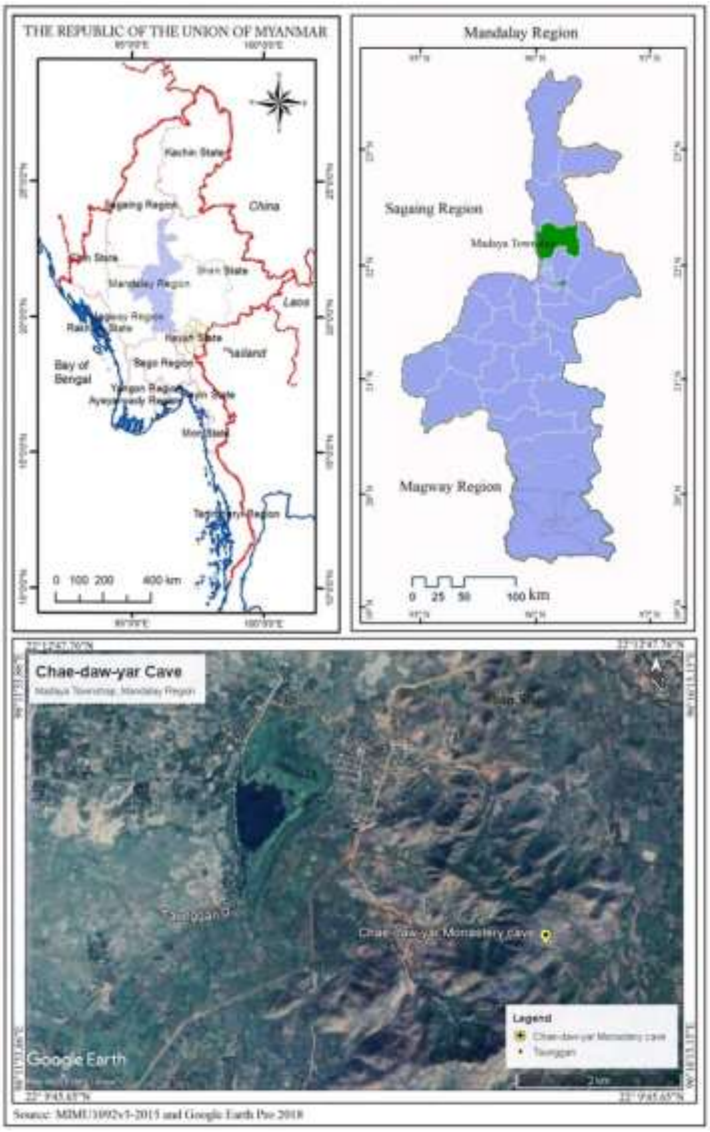

Figure 1 Location: Chae-daw-yar Monastery Cave, Madaya Township.

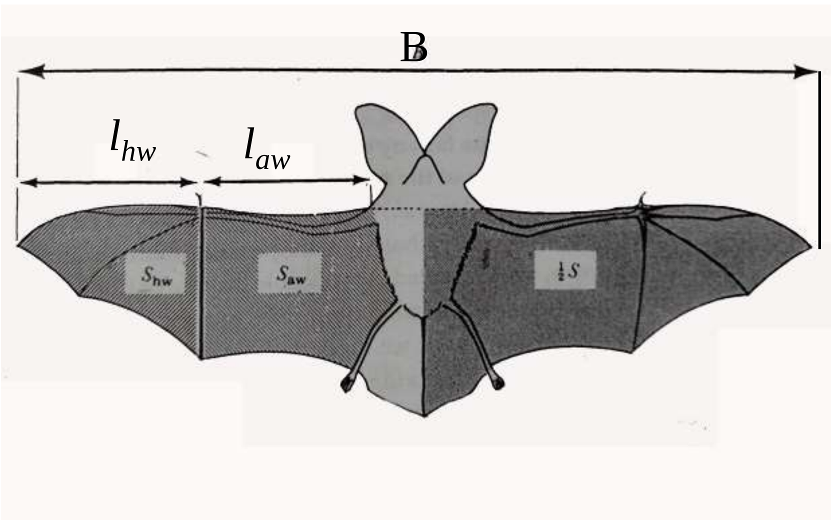

Figure 2 Wing trace of *Taphozous melanopogon* illustrating the flight morphology measurements used (After Norberg and Rayner 1987)

Results

A total of 40 specimens of *Taphozous melanopogon* (20 males and 20 females) were involved to assess the relationship between wing morphology. Morphometric data on the 13 factors to the ecomorphological aspects of the bats wing were examined and mean taken for statistical analysis and evaluation of ecomorphology of wings (Appendix 1).

The results of average body mass, (64.95 kg); forearm, (0.027 mm); wing span, (0.16 m); wing area, (0.018 m^2); aspect ratio, (9.06); wing loading, (15.21 m^2); length of hand wing, (0.182); length of arm wing, (0.168); hand wing area, (0.0058); arm wing area, (0.0092); tip length ratio, (1.09); tip area ratio, (0.65) and tip shape index (1.56) were calculated in males while the average of body mass, (65.5 kg); forearm, (0.0264 mm); wing span, (0.164 m); wing area, (0.018 m^2); aspect ratio, (9.10); wing loading, (14.53 m^2); length of hand wing, (0.176); length of arm wing, (0.163); hand wing area, (0.0060); arm wing area, (0.0092); tip length ratio, (1.09); tip area ratio, (0.63); and tip shape index, (1.44) were calculated in female (Table 1).

Evaluation of was pointed on three major parameters; wing loading (WL), aspect ratio (A) and wing tip shape index (I) between males and females by using t-test. The values of wing loading ($t = .881$, $df = 38$, $p = 0.219$), aspect ratio ($t = -196$, $df = 38$, $p = 0.478$) and wing tip shape index ($t = .843$, $df = 38$, $p = 0.072$) were calculated (Appendix 2). Wing parameters were used to compare body mass (M), forearm (FA), wing span (B), wing areas (S), aspect ratio (A), wing loading (WL), tip length ratio (Tl), tip areas ratio (Ts)and tip shape index (I) between males and females, yielding no significant differences sexes.

The present study, echolocation calls of *T. melanopogon* were recorded in start frequency, 21.62 kHz and end frequency value 35.12 kHz while the FMAXE, 29.85 kHz. The value of maximum frequency 32.55 kHz, minimum frequency 25.53 kHz and duration 4.8 ms while the average frequency value 29.36 kHz were recorded in this study (Figure 3). According to the results, the wing morphology and skull structures were not significantly different in both sexes.

Table 1 Morphometric measurements of males and females of *Tahpozous melanopogon*.

Wing Parameters	Male (N=20)				Female (N=20)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
FA(mm)	0.027	± 0.0017	0.025	0.03	0.0264	± 0.0031	0.021	0.032
Mass(kg)	64.95	± 1.0501	62	66	65.5	± 1	64	68
B^2(m)	0.159	± 0.0215	0.24	0.3	0.1637	± 0.0279	0.11	0.187
S(m^2)	0.0176	± 0.0023	0.0126	0.0204	0.0180	± 0.0023	0.0122	0.0216
A	9.06	± 0.7842	7.77	11.02	9.10	± 1.9354	8.2424	10.3889
WL(N m^2)	15.21	± 2.7825	12.50	21.02	14.5256	± 2.1177	10.9579	19.62
L_{hw}	0.1824	± 0.0107	0.162	0.204	0.1757	± 0.0427	0.002	0.204
L_{aw}	0.1680	± 0.0135	0.13	0.184	0.1632	± 0.0404	0.0021	0.188
S_{hw}	0.0058	± 0.0007	0.0042	0.0066	0.0060	± 0.0008	0.0042	0.0068
S_{aw}	0.0092	± 0.0016	0.0056	0.0112	0.0092	± 0.0015	0.0056	0.012
I	1.5575	± 0.5269	0.9117	2.6875	1.44	± 0.3458	0.91	1.95
T_l	1.0907	± 0.0862	0.9674	1.2769	1.09	± 0.0965	0.95	1.3333
T_S	0.6474	± 0.1009	0.5098	0.8214	0.63	± 0.0734	0.5510	0.82

Abbreviations used are: n, numbers of bats; M, body mass; FA, forearm length; B, wing span; S, wing areas; A, aspect ratio; WL, wing loading; Shw, hand wing area; Saw, arm wing area; L_{hw}, length of hand wing; Law, length of arm wing; Ts, S_{hw}/S_{aw}; Tl, L_{hw}/L_{aw}; I, wing tip shapeindex $I = Ts/(Tl – Ts)$.

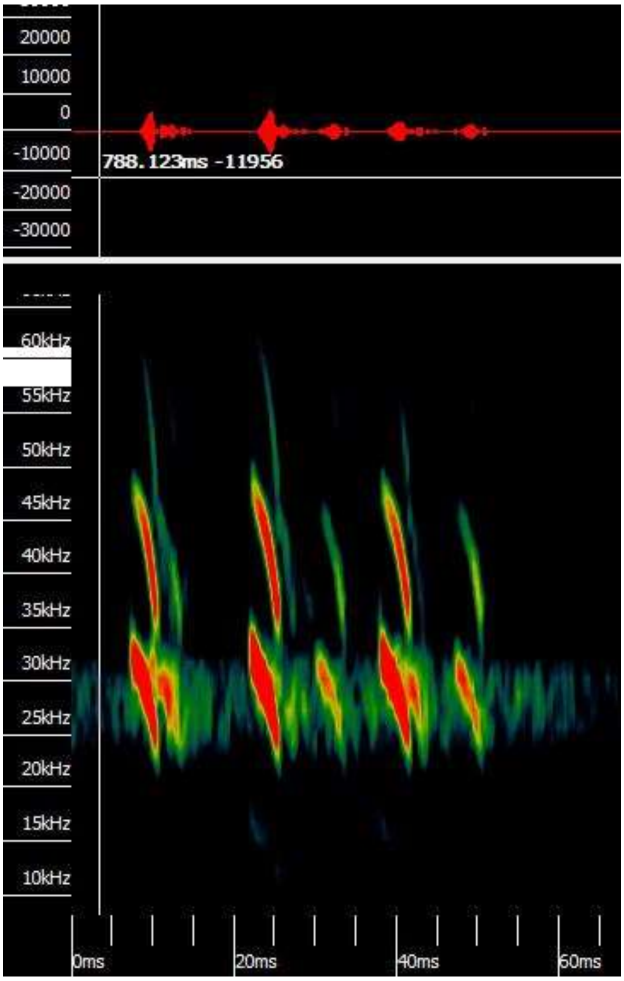

Figure 3 Waveform and sonogram of echolocation pulse from *Taphozous melanopogon*

Discussion

The present study was carried out on wing parameters taken on forty specimens and skull structures of twenty specimens of black-bearded tomb bat in males and females from June 2018 to February 2019. *Taphozous melanopogon* (Emballonuridae) is a medium-sized, bat with the wings moderately long, narrow and tip pointed. Based on the three parameters values of wing loading ($t = 0.881$; $df = 38$, $p = 0.219$); aspect ratio ($t = -196$; $df = 38$, $p = 0.478$) and tip shape index ($t = .843$; $df = 38$, $p = 0.072$) were recorded in male and female. Adams, (1997) stated that wing morphology varies not only with body size but also between sexes and among developmental stages within single species. The wing loading, aspect ratio and mass influence the variation of flight performance, feeding niche and speed. Altringham, (1996) reported that the best examples are perhaps some *Taphozous* species from the emballonurids and other mollossids. They feed in the open, catching insects on the wing. Their fast flight means that they cannot turn tight circles. They would not be good at hunting among trees, or at hovering to pick insects of foliage.

The present study of females, the average wing loading was lower than in males. The females and males of wing loading were (14.53 $m^2 \pm 2.1177$ and 15.21 $m^2 \pm 2.7824$) and while the average wing area of females and males were (0.0180 $m^2 \pm 0.0023$ and 0.0176 $m^2 \pm 0.0023$). But the value of body mass in females is not different with males. The average body mass in females was (0.264 ± 0.0031) while the average body mass in males was (0.0269 ± 0.0017) respectively. Stern *et al*. (1997) studied that wing loading of adult females fluctuated greatly with seasonal changes in body mass. Wing loading of females, a factor of their greater wing areas and lower body mass, was significantly lower than in males. Norberg and Rayner, (1987) stated that the bat with short, rounded wingtips are found to be slow flying, maneuverable bats, in association with low AR and low WL. To be maneuverable, that is to have a small turning circle and fly slowly. The fast, efficient flyers hawking on insects in the open, high WL, high AR species are not very maneuverable. However, they often have pointed wingtips, which increase their agility. Agile bats have the ability to rapidly initiate a roll, altering their flight path. The relationship between wing morphology and agility is therefore complex, involving some important adaptations. Findley (2016) disclosed the wing morphology for 136 species of bats representing 15 families. It is noted that wing area and wing loading were positively correlated with overall size but that wing length was negatively related to the length of hand wing and the length of arm wing variables.

Echolocation calls of *Taphozous melanopogon* were appeared long broadband multi-harmonic frequency-modulated (FM) call and low intensity. Hughes *et al.* (2011) reported that *T. melanopogon* showed the longest narrowband component in its call, and if the curvature of the call could be quantified then species identification within this group may be improved. Norberg and Rayner (1987) reported that *T. melanopogon* was used narrow band echolocation calls at relatively lower frequency (usually less than 40 kHz) in more open area when they were searching for prey.

The study revealed that the value of start frequency was 21.62 kHz and end frequency 35.12 kHz and the peak frequency was 29.85 kHz. Wei *et al* (2008) also recorded 30.10 kHz Guangxi Province in China. Nang Aye Aye Shein (2007) also recorded that the peak frequency value was 28.75 kHz in Patheingyi Township and these results indicated that these features the ability to fly fast in open area or detecting relatively large prey. Lei Lei Thin (2012) recorded that 29.56 kHz at Mandalay University and also stated that start frequency of *T. melanopogon* was 30.67 kHz, end frequency value was 21.94 kHz, and pulse duration value was 6.34 ms respectively. Therefore, the result of the present was quite similar to the above authors.

Conclusion

In the present study, it was observed that the wing span was moderate long, narrow and pointed wingtips while wing loading and aspect ratio were high. Therefore, it is assumed that the bat will have an ability to fast fly in open area and hawk insects at high altitudes. Similarly, Wei *et al*, (2008) also pointed out that aspect ratio and wing loading of *T. melanopogon* were high while wing span was long but tip shape index was found to be low. These features suggest an ability to fly fast in open areas, over treetops, and along the edge of forest or semi-cluttered habitats. Norberg and Rayner (1987) provided an overall view on the ecomorphology of flight and feeding and serve as important foundations. However using the three flight parameters, wing loading, aspect ratio and tip shape index appeared not enough to classify habitat segregation. The present study of wing morphology and echolocation calls may be aid the bats to fly various flight performances to catch the captured prey.

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References

Adams, R. A. (1997). Onset of volancy and foraging patterns of juvenile little brown bats, *Myotis lucifugus*, *Journal of Mammology*, 78: 239-246.

Altringham, J.D., (1996). *Bats Biology and Behaviour, Oxford University*. Oxford, 262 pp.

Bates, P.J.J. and Harrison, D.L., (1997). *Bats of the Indian Subcontinent*. Harrison Zoological Museum Publication. Sevenoaks, 258 pp.

Findley, J. S. (2016). Phenetic relationships among bats of the genus *Myotis*. Downloaded from *http:// sybio.oxfordjournals.org/* at Penn State University.

Hughes, A. C., Satasook, C., Paul.J.J.B., Soisook, P., Sritongchuay, T., Jones, G, and Bumrungsri, S, (2010). Echolocation calls analysis and presence-only modeling as conservation monitoring tools for rhinolophid bats in Thailand. *Acta Chiropterologica*, 12(2): 311-327.

Hughes, A. C., Satasook, C., Paul.J.J.B., Soisook, P., Sritongchuay, T., Jones, G, and Bumrungsri, S, (2011). Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. *Acta Chiropterologica*, 13(2): 447-455.

Jennings, N. V., Parsons, S., Barlow, K. E and Gannon, M. R. (2004). Echolocation calls and wing morphology of bats from the West Indies. Acta Chiropterologica, 6(1): 75-90.

Jung, K., Kalko, E. K. V, and Helversen, O. V. (2007). Echolocation calls in Central American emballonurids bats: signal design and call frequency alternation. *Journal of Zoology*. ISSN, 0952 – 8369.

Lei Lei Thin, (2012). Distribution and ecolocation call analysis of some bats from Mandalay environs. *PhD Dissertation*. Department of Zoology, University of Mandalay. (Unpublished)

Moosman, Jr. P. R. Thomas, H.H, and Veileux, J. P. (2012). Diet of the widespread insectivorous bats *Eptesicus fuscus* and *Myotis lucifugus* relative to climate and richness of bat communities. *Journal of Mammology*, 93(2): 491-496.

Nang Aye Aye Shein, (2013). Species richness and ecological aspects of bat species in Patheingyi Township, Mandalay Region. *PhD Dissertation*, Department of Zoology, University of Mandalay.

Norberg, M. U and Rayner, V. M. J. (1987). Ecological Morphology and flight in bats (Mammalia: Chiroptera): Wing adaptations. Flight Performance, Foraging strategy and echolocation. Philosophical Transcriptions of the Royal Society of London. *Biological Sciences*. 316: No. 1179: 335-427.

Nyo Nyo Tun, (2007). Ecomorphological study on soe insectivorous forest bats of ChayMyitPin hilly range, National Kandawgyi Gardens, Pyin Oo Lwin Township. PhD Dissertation. Department of Zoology, University of Mandalay.

Stern, A.A., Kunz, T.H., and Bhatt, S.S. (1997). Seasonal wing loading and the ontogeny of flight in Phyllostomus hastatus (Chiroptera: Phyllostomidae). *Journal of Mammology:* 78(4): 1199-1209.

Swartz, M.S., Freeman, W.P and Stackwell, F.E. (2003). Ecomorphology of Bats: Comparative and Experimental approaches relating structural design to ecology. *Papers in Natural Resources*: 257-299.

Wei, L., Han, N., Zhang, L., Helgen, K. M., Parsons, S., Zhou, S and Zhang, S. (2008). Wing morphology, echocation calls, diet and emergence time of Black-bearded Tomb bats (*Taphozous melanopogon*, Emballonuridae) from southwest China. *Acta Chiropterologica*, 10 (1):51-59.

Wei, L., Zhou, S. Y., Zhang, L. B., Liang, B., Hong, T. Y and Zhang, S. Y. (2006). Characteristics of echolocation calls and summer diet of three sympatric insectivorous bats species. *Zoological Research*, 27: 235-241.

Weterings, R., Umponstira, C. (2014). Bodyweight-Forearm ratio, Cranial morphology and call frequency rate to prey selection in insectivorous bats. *Electronic Journal of Biology.* 10 (1): 21-27.

Appendix 1

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Mass	Equal variances assumed	3.973	.053	.562	38	.577	.00045	.00080	-.00117	.00207
	Equal variances not assumed			.562	29.538	.578	.00045	.00080	-.00119	.00209
FA	Equal variances assumed	.306	.584	-1.696	38	.098	-.55000	.32424	-1.20639	.10639
	Equal variances not assumed			-1.696	37.910	.098	-.55000	.32424	-1.20644	.10644
B^2	Equal variances assumed	.015	.904	-.622	38	.537	-.00411	.00660	-.01748	.00926
	Equal variances not assumed			-.622	37.841	.537	-.00411	.00660	-.01748	.00926
S	Equal variances assumed	.045	.833	-.497	38	.622	-.00036	.00072	-.00183	.00111
	Equal variances not assumed			-.497	37.985	.622	-.00036	.00072	-.00183	.00111
A	Equal variances assumed	.513	.478	-.196	38	.845	-.04291	.21841	-.48506	.39923
	Equal variances not assumed			-.196	35.063	.845	-.04291	.21841	-.48628	.40045
WL	Equal variances assumed	1.561	.219	.881	38	.384	.68898	.78188	-.89385	2.27182
	Equal variances not assumed			.881	35.482	.384	.68898	.78188	-.89755	2.27552
L_{hw}	Equal variances assumed	2.191	.147	.396	38	.695	.00390	.00986	-.01605	.02385
	Equal variances not assumed			.396	21.386	.696	.00390	.00986	-.01657	.02437
L_{aw}	Equal variances assumed	1.764	.192	.504	38	.617	.00479	.00952	-.01447	.02406
	Equal variances not assumed			.504	23.220	.619	.00479	.00952	-.01488	.02447
S_{hw}	Equal variances assumed	2.338	.135	-.164	38	.871	-.00004	.00024	-.00053	.00045
	Equal variances not assumed			-.164	35.110	.871	-.00004	.00024	-.00054	.00046
S_{aw}	Equal variances assumed	1.376	.248	-.268	38	.790	-.00013	.00049	-.00111	.00085
	Equal variances not assumed			-.268	37.709	.790	-.00013	.00049	-.00111	.00085
I	Equal variances assumed	3.423	.072	.843	38	.405	.11877	.14092	-.16651	.40406
	Equal variances not assumed			.843	32.808	.405	.11877	.14092	-.16800	.40555
Tl	Equal variances assumed	.179	.674	-.059	38	.953	-.00172	.02892	-.06026	.05683
	Equal variances not assumed			-.059	37.526	.953	-.00172	.02892	-.06028	.05685
Ts	Equal variances assumed	2.667	.111	.469	38	.641	.01309	.02789	-.04337	.06956
	Equal variances not assumed			.469	34.722	.642	.01309	.02789	-.04355	.06974

Appendix 2

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
A	Equal variances assumed	.513	.478	-.196	38	.845	-.04291	.21841	-.48506	.39923
	Equal variances not assumed			-.196	35.063	.845	-.04291	.21841	-.48628	.40045
WL	Equal variances assumed	1.561	.219	.881	38	.384	.68898	.78188	-.89385	2.27182
	Equal variances not assumed			.881	35.482	.384	.68898	.78188	-.89755	2.27552
I	Equal variances assumed	3.423	.072	.843	38	.405	.11877	.14092	-.16651	.40406
	Equal variances not assumed			.843	32.808	.405	.11877	.14092	-.16800	.40555