Population Estimate of the Chiropteran Emergence at Stinking Hole, Dominica

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OBJECTIVE

The purpose of this study is to determine the size of the Chiroptera emergence at the Stinking Hole in the St. Paul Parish of Dominica. Through photographic documentation I was able to create an estimate of the size of the entire emergence. A series of histograms were created to graphically summarize the number of emerging bats over time.

INTRODUCTION

Stinking Hole, also known as "Tou Santi" in the local Kweyol, is a lava tube lying in the primary montane rainforest of the Morne Trois Pitons National Park. It is located at 15°20'N, 61°22'W. This rain forest habitat is characterized by its dominant trees reaching 40m or greater and dense canopy cover (Nicolson, 1991). Its ecosystem is encompassed with thousands of species of magnificent flora and fauna. Stinking Hole is inhabited by several species of Chiroptera. Documented species include the nectivorous Gray Antillean Fruit-eating Bat (*Brachypylla cavernarum),* the nectivorous Antillean Long-tongued Bat (*Monophyllus plethodon),* and the insectivorous Gray Funnel-eared Bat (*Natalus stramineus)* (Genoways et al., 2001). Stinking Hole has been studied on several occasions, but an estimate of total emergence size has never been conducted.

Evening emergence of bat species is one of the most studied aspects of bat behavior (Jones and Rydell, 1994). Timing, pattern, and size of Chiropteran emergences will vary among species and roosting cites. Cave roosting bats must pass through intricate paths which will directly affect the rate of the emergence. Pulses of bats emerge from the caves entrance, funnel, and depart to forage. In between the large pulses, bats continue to emerge in the same pattern. The number of bats and time spent funneling will vary through the entire emergence.

Many variables must be factored in estimating the size of a bat emergence. This process is tedious and complete accuracy is not possible. Rough estimates can be obtained through understanding emergence patterns of select study sites. Technological advances have been extremely beneficial to this process. Successful studies have used digital video camera recordings in documenting these events. However, this study will provide an insight to the option of photographic documentation.

Chiropteran populations play a vital role in Dominica's ecosystems. Estimating the population

size of the bats in Stinking Hole could potentially provide useful insight to further research. Predator prey relationships, community ecology, foraging patterns and behavior are all aspects that could benefit from knowing an estimated population size of the bats in Stinking Hole. Stinking Hole is an exceptional site for this study.

METHODS AND MATERIALS

Devising a precise plan for the purpose of this study was difficult. I read several studies conducted on similar research to obtain a general idea of how to accomplish this task. A similar study of estimating emergence size was conducted at Fort Hood at the Cave Myotis (*Myotis velifer)*. The Cave Myotis population was estimated using a digital video camera recorder which allowed for a count in a one second sample with in each minute of the emergence (Land et al., 2003). This provided structure and a comparison for my study. In speaking with Dr. Lacher and Dr. Woolley, we were able to devise a basic plan for a trial run of the emergence on the night of June 2nd.

Camera placement and setting was crucial. Safety concerns resulted in cave measurements set for a later date. We set the camera 9 feet 6 inches from the cave entrance. Dr. Woolley took multiple photographs at various settings (i.e. multiple ISO values, 1 picture per second, and a series of 3 pictures every 6 seconds and 6 pictures every 6 seconds) through the entire emergence. He experimented with multiple exposure parameters. I created a natural frame using the vegetation to mimic the frame of the camera. This frame began at the caves opening and measured 4 feet 8 inches high. I used a stop watch to create an estimated time that it took the bats to funnel from the cave's opening to the top of the frame. With some variation, I estimated this to be a 3 second process for the first 40 minutes and a 2 second process for the remaining emergence. The emergence began at 1835 and we left the site at 1945, prior to the end of the emergence. Upon arrival to ATREC, Dr. Woolley and I discussed his photographs. Each exposure parameter yielded adequate pictures. Bats could be counted easily using Photoshop and other programs. We decided to take one picture every 30 seconds to have a large sampling size. This "trial night" provided a good idea of how to carry out the final study.

We arrived at Stinking Hole on June 4th at 18:60 and set up the camera as carried out on our trial night. Using rope and an 8X10 tarp we created a rain cover for the camera. I attached my climbing throw bag to a rope to measure the width and length of the cave opening. Using a 100

foot measuring tape I measured the distance from the camera to the nearest end of the hole (4 feet 8 inches). I also measured the length and width of the frame viewed from the camera (9 feet 6 inches X 8 feet 9 inches). Dr. Woolley's Nikon D1X digital camera settings were 28 mm wide angle lens, ISO 400, aperture 4.0, SB 800 Flash set for TTL exposure at +1 EV I. The emergence began at 18:35. I used a stop watch to time every 30 seconds that the picture would need to be taken. Dr. Woolley took the picture when I said "now". This pattern continued through the entire emergence. I took an overall estimate of the time it took for the bats to fly out of the frame during fluctuating sizes in bat emergence. We continued to time and photograph the emergence for 130 minutes. At this time I noted that remaining bats were roosting on the sides of the cave. They would make a short flight and return to their perch. Therefore continuing to count these bats would have resulted in an overestimate in population size.

Dr. Woolley uploaded the 278 pictures taken that the calculations would be derived from. I began counting the bats in Photoshop CS3 using the count tool to mark each individual bat. I counted every 4^{th} picture, (i.e. every 2 minutes). I used a side by side comparison of a base line picture taken before the emergence began. This enabled me to decipher between a bat versus a rock, rain, or vegetation. I recorded the totals for each picture and exported them to an Excel spreadsheet. I came up with a total population and created a histogram to graphically summarize my results. I used a multiplier of 60 for the first 40 pictures and 40 for the remaining shots to account for the 3 second and 2 second time lag that it took for each bat to fly out of the frame. To create a lower margin of error, I calculated a new total population size using every other 4^{th} picture and followed the same criteria stated above. I combined both results to form an overall estimate of bats photographed every 2 pictures, or every 1 minute.

RESULTS

The first data set (Table 1) shows a recorded total of 1,230 bats counted on Photoshop. Data listed are recorded in increments of 4 beginning with the first picture taken. A multiplier of 40 was used to represent the 3 seconds it took for bats to fly out of the frame and a multiplier of 60 was used to represent the 2 second counts. This was multiplied with the numbers counted on Photoshop and resulted in a product of 62,620 bats. The first histogram (Figure 1) represents the total bats counted in the first sample.

The second data set (Table 2) represents the bats emerging at increments of 4 starting from the

third picture. The total bats counted on Photoshop for this group of pictures was 1,384. The same multipliers were used. The multipliers and counts combined resulted in a total of 70,220 bats. The second histogram (Figure 2) represents the same pattern but starts at the third photograph.

The third data set (Table 3) is a combined total of Table 1 and 2. This creates a record of bat counts at every minute, or every 2 pictures. The histogram depicted in Figure 3 visually represents a combination of both data sets. Due to counts every minute, the multiplier was changed to 30 for the first 80 pictures and 20 for the remaining pictures. Counting bats every minute resulted in a lower margin of error in the population estimate.

Tables and Figures:

Picture Number	Count	Multiplier	Product
1	8	40	320
5	17	40	680
9	16	40	640
13	25	40	1000
17	25	40	1000
21	11	40	440
25	29	40	1160
29	11	40	440
33	16	40	640
37	30	40	1200
41	28	40	1120
45	19	40	760
49	36	40	1440
53	45	40	1800
57	44	40	1760
61	27	40	1080
65	31	40	1240
69	48	40	1920
73	45	40	1800
77	48	40	1920
81	53	60	3180
85	22	60	1320
89	39	60	2340

93	27	60	1620
97	33	60	1980
101	29	60	1740
105	25	60	1500
109	30	60	1800
113	23	60	1380
117	19	60	1140
121	17	60	1020
125	21	60	1260
129	21	60	1260
133	18	60	1080
137	8	60	480
141	12	60	720
145	23	60	1380
149	7	60	420
153	11	60	660
157	26	60	1560
161	14	60	840
165	10	60	600
169	8	60	480
173	3	60	180
177	12	60	720
181	8	60	480
185	11	60	660
189	11	60	660
193	9	60	540
197	5	60	300
201	12	60	720
205	7	60	420
209	11	60	660
213	4	60	240
217	4	60	240
221	8	60	480
225	12	60	720
229	1	60	60

233	8	60	480
237	5	60	300
241	14	60	840
245	8	60	480
249	5	60	300
253	10	60	600
257	5	60	300
261	2	60	120
	1230		62620

Table 1. Data collected for bats counted every 4th picture (starting at picture 1)

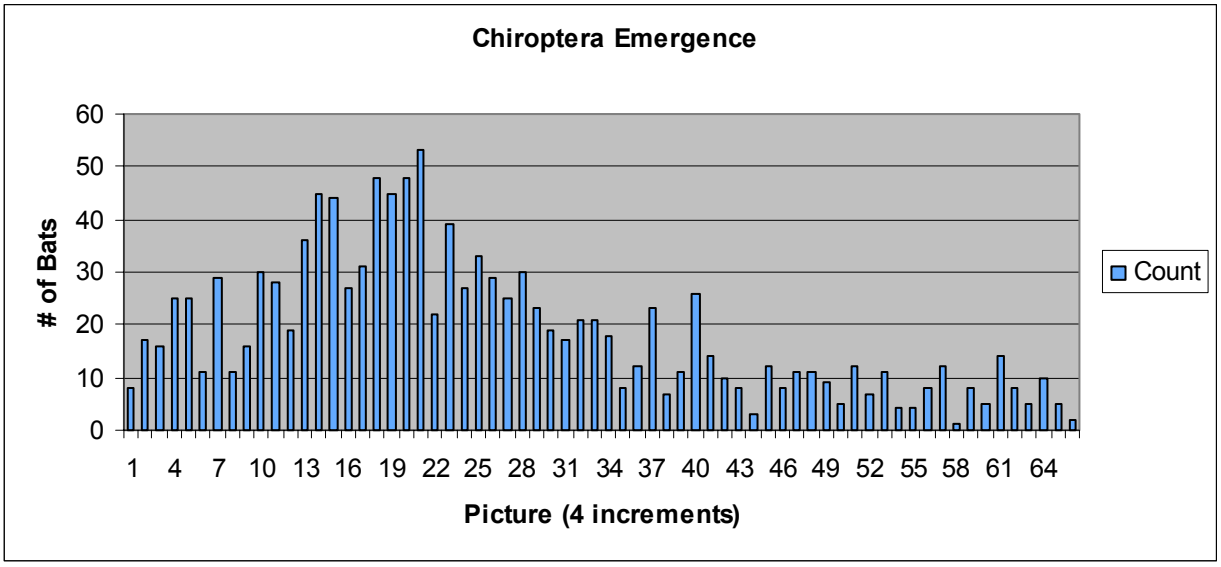

Figure 1. Size of bat emergence recorded every 2 minutes (4 picture increments)

Picture Number	Count	Multiplier	Product
3	1	40	40
7	18	40	720
11	44	40	1760
15	17	40	680
19	36	40	1440
23	25	40	1000

27	45	40	1800
31	36	40	1440
35	42	40	1680
39	41	40	1640
43	20	40	800
47	40	40	1600
51	26	40	1040
55	41	40	1640
59	31	40	1240
63	43	40	1720
67	44	40	1760
71	43	40	1720
75	48	40	1920
79	47	60	2820
83	37	60	2220
87	26	60	1560
91	33	60	1980
95	31	60	1860
99	21	60	1260
103	37	60	2220
107	27	60	1620
111	24	60	1440
115	23	60	1380
119	20	60	1200
123	10	60	600
127	16	60	960
131	22	60	1320
135	13	60	780
139	21	60	1260
143	14	60	840
147	20	60	1200
151	13	60	780
155	14	60	840
159	18	60	1080
163	19	60	1140

167	3	60	180
171	24	60	1440
175	13	60	780
179	10	60	600
183	6	60	360
187	6	60	360
191	8	60	480
195	7	60	420
199	13	60	780
203	11	60	660
207	10	60	600
211	17	60	1020
215	6	60	360
219	19	60	1140
223	10	60	600
227	5	60	300
231	7	60	420
235	5	60	300
239	16	60	960
243	13	60	780
247	18	60	1080
251	4	60	240
255	6	60	360
	1384		70220

Table 2. Data set for bats counted every 4th picture (starting at picture 3)

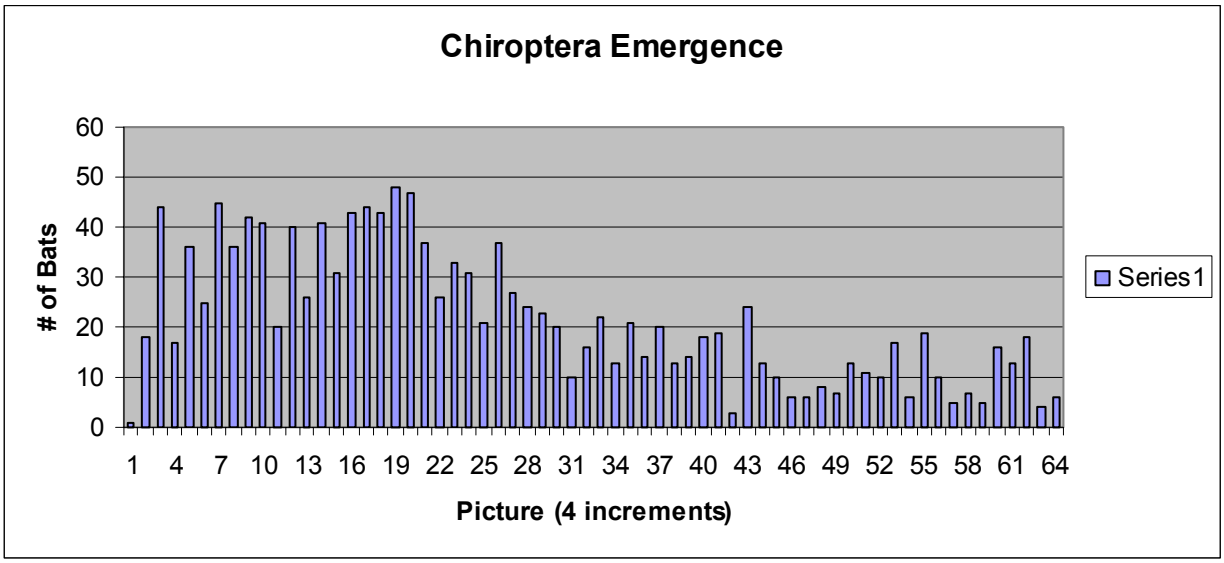

Figure 2. Size of bat emergence recorded every 2 minutes (4 picture increments)

Picture Number	Count	Multiplier	Product
1	8	20	160
3	1	20	20
5	17	20	340
7	18	20	360
9	16	20	320
11	44	20	880
13	25	20	500
15	17	20	340
17	25	20	500
19	36	20	720
21	11	20	220
23	25	20	500
25	29	20	580
27	45	20	900
29	11	20	220
31	36	20	720
33	16	20	320
35	42	20	840
37	30	20	600
39	41	20	820
41	28	20	560
43	20	20	400
45	19	20	380
47	40	20	800
49	36	20	720
51	26	20	520

53	45	20	900
55	41	20	820
57	44	20	880
59	31	20	620
61	27	20	540
63	43	20	860
65	31	20	620
67	44	20	880
69	48	20	960
71	43	20	860
73	45	20	900
75	48	20	960
77	48	20	960
79	47	20	940
81	53	30	1590
83	37	30	1110
85	22	30	660
87	26	30	780
89	39	30	1170
91	33	30	990
93	27	30	810
95	31	30	930
97	33	30	990
99	21	30	630
101	29	30	870
103	37	30	1110
105	25	30	750
107	27	30	810
109	30	30	900
111	24	30	720
113	23	30	690
115	23	30	690
117	19	30	570
119	20	30	600
121	17	30	510
123	10	30	300
125	21	30	630
127	16	30	480
129	21	30	630
131	22	30	660
133	18	30	540
135	13	30	390
137	8	30	240
139	21	30	630
141	12	30	360
143	14	30	420
145	23	30	690
147	20	30	600

149	7	30	210
151	13	30	390
153	11	30	330
155	14	30	420
157	26	30	780
159	18	30	540
161	14	30	420
163	19	30	570
165	10	30	300
167	3	30	90
169	8	30	240
171	24	30	720
173	3	30	90
175	13	30	390
177	12	30	360
179	10	30	300
181	8	30	240
183	6	30	180
185	11	30	330
187	6	30	180
189	11	30	330
191	8	30	240
193	9	30	270
195	7	30	210
197	5	30	150
199	13	30	390
201	12	30	360
203	11	30	330
205	7	30	210
207	10	30	300
209	11	30	330
211	17	30	510
213	4	30	120
215	6	30	180
217	4	30	120
219	19	30	570
221	8	30	240
223	10	30	300
225	12	30	360
227	5	30	150
229	1	30	30
231	7	30	210
233	8	30	240
235	5	30	150
237	5	30	150
239	16	30	480
241	14	30	420
243	13	30	390

245	8	30	240
247	18	30	540
249	5	30	150
251	4	30	120
253	10	30	300
255	6	30	180
257	5	30	150
261	2	30	60
	1890		65950

Table 3. Data set of bats counted every 2 pictures (one count per minute)

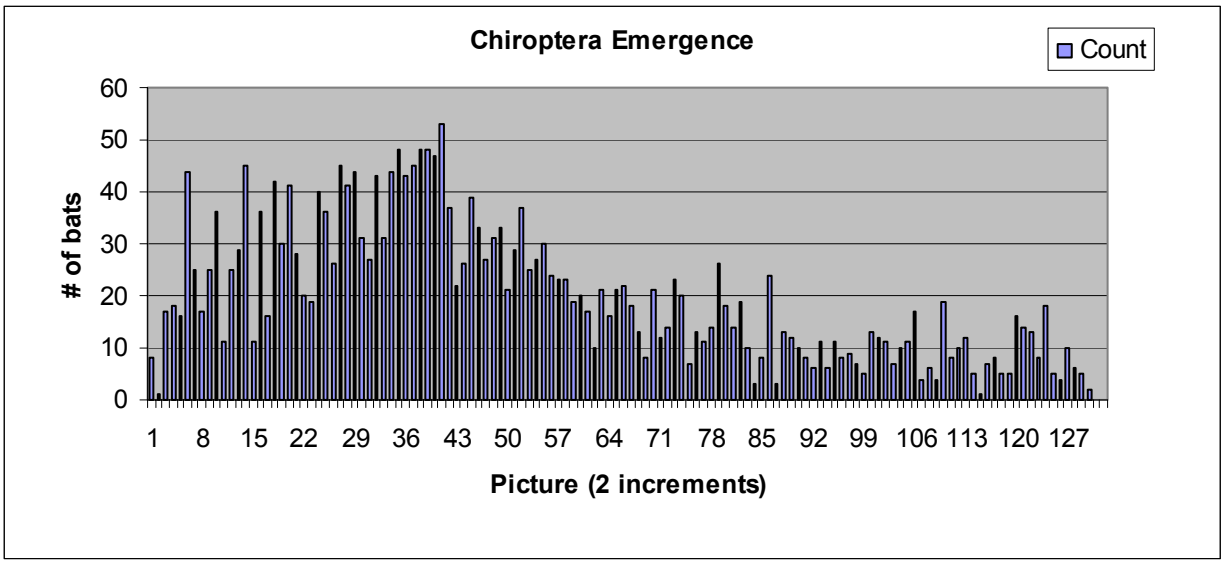

Figure 3. Size of bat emergence recorded every minute (2 picture increments)

DISCUSSION

The emergence began at 1835 hours. The time interval that it took for the bats to fly out of the frame was a crucial factor to apply in this study. During the first 40 minutes of the emergence, large pulses of bats would emerge approximately every 10 minutes (as indicated in Fig 3). Other than these large pulses, the rate of the emergence was relatively constant. It took the bats approximately 3 seconds to fly out of the camera's frame of view. I noticed that after 40 minutes the number of bats emerging decreased substantially. The bats ceased to funnel the remaining

time of the emergence. This allowed the bats to fly out of my frame in approximately 2 seconds.

Each histogram is relatively similar in emergence patterns. All graphs depict the large pulses of bats emerging for the first 40 minutes and decreased from there after. The flight speed was a crucial element to address in estimating a total number of bats. The results above depict what I visually observed and noted during the emergence. It is important to note that steady rain occurred from minutes 20 to 40.

I concluded timing and photographing of the emergence at 2045. At this time I noticed that the remaining bats were roosting in the cave, flying out momentarily and then returning to the cave's wall to perch. Therefore, continued recordings would have resulted in an overestimate in the population size of Stinking Hole.

CONCLUSION

Stinking Hole in the Morne Trios Pitons National Park of Dominica contains records of 3 species of bats: *Brachypylla cavernarum*, *Monophyllus plethodon,* and *Natalus stramineu.* The bat emergence was recorded over a 130 minute time frame. Using photographic records of the emergence at 1 minute intervals and an adequate time frame of flight out of the camera frame, I was able to create histograms to graphically summarize the population size of the entire emergence. Figures 5 and 6 were most beneficial to obtaining the overall estimated population size. Recording counts of bats for every minute provided a lower margin of error than recordings every 2 minutes. The data collected and calculated yielded a total population of 65,950 bats at Stinking Hole.

This study gives insight to the efficiency of digital photography in documenting a bat emergence. However, it is a rough estimate. A major assumption I made was that there were no other openings to this lava tube for the bats to emerge from. This study can pose as a prefix to later studies. Various ecosystem functions can be more clearly understood with an ideal estimate of the size of Stinking Hole's bat population.

ACKNOWLEDGEMENTS

I would like to thank Dr. Lacher for providing me with a brilliant project idea and the literature to aid in formatting the process. I would like to thank Dr. Woolley for photographing the emergence

and explaining in depth the programs that correlated with my project. I learned a substantial amount about photography, Photoshop, and excel through the assistance I obtained during this course. I appreciate the amount of time and effort that both Dr. Lacher and Dr. Woolley spent to ensure that my project was a success.

Table Legend

Table 1- Data set of emergence in 4 picture increments (a count every 2 minutes) beginning at the first photograph.

Table 2- Data set of emergence in 4 picture increments (a count every 2 minutes) beginning at the third photograph.

Table 3- Combined data set of Tables 1 and 2 creating a count in 2 picture increments (a count every minute)

Figure Legend

Figure 1- Pattern of emergence in 4 picture increments (a count every 2 minutes) beginning at the first photograph.

Figure 2- Pattern of emergence in 4 picture increments (a count every 2 minutes) beginning at the third photograph.

Figure3- Combined data set of Figures 1 and 2 creating a count in 2 picture increments (a count every minute)

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