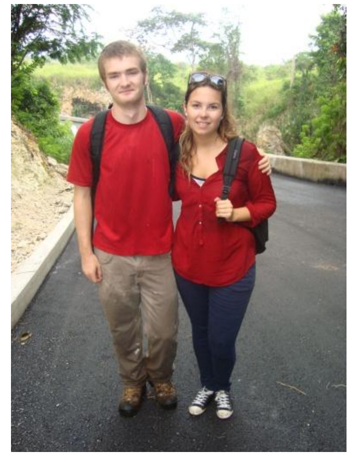
The Mechanics of the Bounty System:

Public Collection and Population Estimations of *Achatina fulica*

By Heather Cross and Colin LaRoche



Heather Cross and Colin LaRoche are students studying at McGill University's Bellairs camps whilst taking part of the 2012 Barbados Interdisciplinary Topics Study.

Summary

Achatina fulica, more commonly known as the Giant African Snail (GAS), is an air-breathing land snail. It originated in Africa and has since then immigrated to many other countries worldwide. It has become a growing problem to most inhabitants of the island (Fields, 2007). According to the Global Invasive Species Database, *A. fulica* is one of the top one hundred invasive species in the world (Cowie, 2010).

The Giant African Snail has been a concern to crop growers as well as land owners in Barbados because of its land destruction capabilities. Since its invasion of Barbados in 2000, the GAS population has multiplied to the point where total eradication, though ideal, is not feasible. Instead, controlling its population has become the main focus (Fields et al., 2006).

This summer, our group further examined the use of the Bounty System as a control mechanism, providing the Ministry of Agriculture and Rural Development with greater details about participation in the Bounty System as well as a possible method of GAS population estimation.

The Importance of Population Control

GAS is a possible intermediate host for the Rat Lungworm (*Angiostrongylus cantonensis*), a nematode that can cause eosinophilic meningitis in humans (Hung-Chin Tsai et al., 2003), among several other parasites and angiostrongylid nematodes. Thus, The Bounty System also serves an important preventative mechanism for the spread of this disease. As GAS populations grow, these nematodes could become an increasing health hazard to Barbadians and tourists alike. If populations continue to rise and therefore cause the rat population to rise as well, the GAS problem could become a threat to the tourism industry, which is the main economic industry on the island.

Goals and Objectives

The goal of this project is to provide the Ministry of Agriculture and Rural Development with the information it needs to adjust the Bounty System to best deal with the GAS population. This was achieved through two separate objectives. The first completed objective (objective 1) was to conduct a thorough and updated data review on the Bounty System to include all current information provided by Ian Gibbs, head entomologist at the Ministry of Agriculture and Rural Development. The second completed objective (Objective 3) was to work with Professor Fields to develop an index for GAS population estimation in Barbados. In so doing, we hope to give the Ministry of Agriculture, UWI staff, and future BITS students the tools they need to contribute accurate information to the Bounty System over the years to come.

Project Activities

Data Collection and Trend Perceptions

Ian Gibbs provided us with the raw data, including pounds collected per parish, names of collectors, pounds per collector and location of collectors from May 2011 through June 2012. The data and analysis is presented in a clear and concise format. We graphed and charted most of the information in order to make it easily accessible to experts and those unfamiliar with the Bounty System alike. Some trends include:

- Pounds of GAS collected per month
- Pounds of GAS collected per parish
- Number of collectors per parish
- The number of pounds collected per collector by parish (average per collector).
- List of the top 20 collectors between the months of May 2011 to June 2012, the parish they are from and how many pounds they collected.

We also contrasted the island's rainfall patterns with the collection patterns of GAS to determine whether the two were in fact linked. Our group compiled rainfall data for 2009, 2010 and 2011 and cross checked this data with tons of GAS collected per month. Conclusions drawn from the data analysis brought to light long term trends in GAS collection over the past three years.

GAS Population Estimation

Rather than attempt to conduct an island-wide population estimate, we chose to conduct smaller-scale investigations which are designed to create an index on changes in the GAS population. Currently, the overwhelming majority of quantitative data available on *A. fulica* populations on the island is from the Bounty System itself. This information, based on rates of collection, is extremely useful and analyzed in depth in Objective 1. However, forming a model of the *A. fulica* population solely based on information collected by the Bounty System can run the risk of providing misleading or false information. As such, we hope that the development of a second, independent, quantitative index will provide an important "second look" at the *A. fulica* population, and can either confirm or call in to question results reported by the Bounty System.

Fig.3. Colin LaRoche setting the quadrat boundary

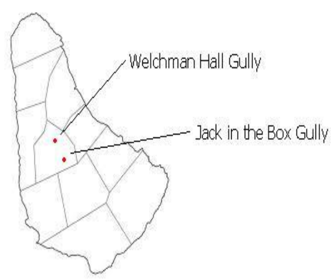
This index was developed to fulfill several criteria:

1)The index is representative of the impact of *A. fulica* on the economic, aesthetic and ecological health of Barbados.

2)The index is labour and cost-effective.

3)The index is completely independent of information collected by the Bounty System; this prevents the index from being affected by factors which skew the results produced by the Bounty System.

Methods and Procedure



Two gullies, Welchman Hall Gully and Jack in the Box Gully, were selected as the test sites. These two sites are situated in St. Thomas, relatively close to one another in order to eliminate as much variation between the two sites based on latitude or longitude (Craze et al., 2002) as possible. Thirty 2m by 2m quadrats were collected, with 30 being the minimum number recommended. Populations were assessed according to an quadrat-based procedure, and an estimate was calculated according to the equation

$$\hat{P} = \frac{nA}{a} = \frac{n}{SF}$$

Where $\hat{P}$ is the population estimate required, a is the area sampled and A is the total area of the gully. The values of A for Welchman Hall Gully (15 acres) and Jack in the Box Gully (18.11 acres) were obtained from Deborah Branker and area calculation software based off of Google Maps respectively.

In order to prevent selection bias, a marker was thrown at random (first to the investigator's right, then to the left), while walking down the central path of each gully. Every time the marker landed, the rear right corner of the quadrat (relative to the position the marker was thrown from) was placed at that exact location, and 2m measured out at 90 degree angles. This was done throughout the length of each gully. A complete search of each $4m^2$ quadrat was conducted, with leaf litter being searched fully, and trees being searched to a height of 2m. The use of many quadrats increases the data with which statistical analysis can be performed. The number of live *A fulica* specimens, number of *A. fulica* shells, and general vegetation profile of the quadrat was recorded.

Results and Conclusions

Objective 1 –Data Collection from the GAS Bounty System

The Bounty System seemed to have brought in the most GAS in 2009 and then lower numbers in the subsequent years.

Date	Pounds Collected (lbs)
February 2009-December 2009	375 255
January 2010-December 2010	218 545
January 2011-December 2011	286 163
January 2012-June 2012	70 089
February 2009-June 2012	950 052

Furthermore, the yearly rainfall patterns and the monthly collection patterns are related. The collection amounts seem to peak roughly two months before the rainy season peaks the fall. This suggests that while GAS does like wet, moist living conditions, too much water may not be ideal collecting conditions.

Objective 3 –GAS Population Estimation

Both Gullies yielded significant numbers of *A. fulica*. Welchman Hall Gully yielded a total of 12 individuals, with a density of 0.1 individuals/m^2, while Jack in the Box Gully yielded 67 individuals, with a density of 0.56 individuals/m^2. These values are much lower than those of gullies examined by Dr. Fields in 2007, which had an average of 1.73 individuals/m^2.

A. fulica shells in Welchman Hall Gully totaled 383, with a density of 3.19 shells/m^2, versus a total count of 560 and a density of 4.67 shells/m^2 for Jack in the Box Gully. There were 32 shells found for every live snail in Welchman Hall Gully, against only 8.4 shells for every live snail in Jack in the Box Gully. This may be a result of the management practices of Welchman Hall Gully, including molluscicide use, the most recent application of which was approximately a month before sampling.

The population estimates based on a quadrat sampling method vary widely; according to the data collected, the population of Welchman Hall Gully consists of approximately 6070 individual *A. fulica* based on an area of 60 702.85 m^2 or 15 acres. Based on the quadrat sampling method, the population of *A. fulica* is 40 919 individuals over an area of 73288.6 m^2.

These population estimates, however, are based on imperfect data. The graphs detailing Shells and GAS numbers per quadrat at Welchman Hall and Jack in the Box gullies show considerably agglomeration towards lower values even upon only cursory inspection. When compared to a Poisson distribution comparing the percentage probability of finding a certain number of GAS in a given quadrat to the percentage of GAS actually found in a quadrat, quadrats with very high and very low numbers of snails are consistently overrepresented.

Issues with sample size and statistical significance were addressed by clearly identifying agglomerations in data and subsequent inaccuracies, as well as comparing with previous collected data such as that of Dr. Fields.

Recommendations for Future Study

A bounty system is an imperfect population control measure because although it is profitable to capture and bring in GAS to the Ministry, it is even more profitable to ensure that the population survives to keep breeding so that the collector's source of revenue is stable. Considering the number of pounds that the top 20 collectors from May 2011 through June 2012 brought in, the Bounty System provided certain collectors with a fair amount of compensation

As previously stated, GAS also poses a threat to the tourism industry on the island because of its potential to carry *A. cantenesis*. It is therefore important to assess what businesses in the tourism industry are doing to combat GAS. For further projects, we suggest conducting interviews with various tourism sites on the island to see how they are dealing with the problem of GAS.

With respect to the establishment of a population index, no reliable marker has yet been identified as to its accuracy. Currently, though comparisons of collected data to a normal distribution and the calculation of variance provide some idea as to the precision of population estimates, but the picture is as of yet incomplete. More information must be collected on *A. fulica* populations, in order to establish a clearer idea of which data points are within the norm and which ones are outliers.

There are two possible courses of action that future students can take: the first involves conducting population estimates across a wide variety of terrains including, but not limited to, the gullies surveyed in this investigation. This would allow for the beginning of an index used to measure changes in GAS density over the years. The second course of action would address what we perceived as weaknesses in the Bounty System. Notably this course of action would determine where and how GAS collection takes place, if not in the gullies by individual collectors.

Acknowledgements

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Appendix 1