The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Jeanette Moss
Project title	Recent trends in recruitment and environmental limiting factors for the Sister Islands Rock Iguana, *Cyclura nubila caymanensis*
RSG reference	
Reporting period	2016-10
Amount of grant	£4,975
Your email address	jbm650@msstate.edu
Date of this report	16-Nov-2016

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Estimate survivorship and population size of 2015 hatchling cohort		X		Recapture rates in 2016 were insufficient to calculate cohort metrics without very large margins for error; however, with improvements in methodology and sample size we anticipate greater success in 2017.
Investigate the impact of environmental and community covariates on recruitment		X		We assessed the impacts of temperature, chamber depth, and spatial clustering on hatching success and timing of emergence in individual nests and identified correlations between nest density and native predator density at communal nest sites. Preliminary evidence suggests that natal environments may have latent effects on juvenile survivorship and that selective pressures may be heightened in the first year.
Increase genetic sampling efforts to estimate degree of inbreeding depression and rates of polyandry			X	Over 400 hatchlings and 25 known mothers were sampled in 2016, a near doubling of 2015's 220 hatchlings and ~10 known mothers.
Engage local community to raise awareness and initiate long-term management objectives		X		Our research team attended meetings of the Little Cayman National Trust and provided regular project updates. A poster featuring on-going SIRI research is now displayed in the National Trust building. Furthermore, we have initiated discussions with board members about land prioritisation

				and important conservation measures. The community assisted our team in monitoring and reporting road kills throughout the season. Our research was featured in an article in the local news outlet, *The Cayman Compass*. Negotiations continue with the Cayman Islands Department of Environment and outside funding agencies to organise a feral cat eradication effort on Little Cayman.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

The recapture rate for hatchlings tagged in 2015 was extremely low. Only three of 228 hatchlings tagged in 2015 were recaptured as yearlings in 2016. This paucity of recaptures compromises our attempts to estimate the number of hatchlings emerging in a season. There are several reasons recapture rates may be low. While we anticipated many of these factors, we underestimated their impact on our current study. Being smaller and generally more timid than adults, younger age classes are often underrepresented in mark-recapture studies of iguanids (Pérez-Buitrago and Sabat 2007). Also, while little is known about habitat use patterns among juveniles relative to adults, prior work on a closely related species suggests animals at this stage are highly motile and experience high mortality rates (Knapp *et al.* 2010). While our re-sight rate was insufficient to apply common metrics, such as the Lincoln-Peterson index, to calculate cohort size effectively, the comparatively large number of new yearling captures (n=33) does allow for a crude estimate. By contrasting the number of recaptures, given the number of animals tagged in 2015, with the number of new captures, the cohort size of hatchlings emerging in 2015 was likely large. The maximum likelihood estimate is 2,736 with a 95% confidence interval of 1,046 to 7,400.

Despite the limitations imposed by the yearling recapture rate, investigations of juvenile survivorship, growth, and dispersal via mark-recapture or re-sight of yearlings and sub-adults provided some valuable new insights into SIRI population dynamics and natural history. We employed our preliminary dataset to address patterns of growth and movement. Our mark-recapture data indicates that growth rates in the first year are highly variable and natal dispersal can be unpredictable. This extreme variation may result in the selective elimination of a large proportion of the cohort, especially when environmental conditions are unfavourable. Since hatching success

on Little Cayman is very high, attrition is more likely to take a toll during this first-year life stage. By taking steps to improve our encounter probability (i.e. increasing the marked hatchling population from 228 in 2015 to 423 in 2016 and expanding upon regular search areas to allow for greater range of natal dispersal) we anticipate greater success in sampling marked yearlings, 2-year olds, and sub-adults in 2017. Furthermore, what we have learned from splitting our efforts in 2016 between mark-recaptures and nesting work is that future investigations of recruitment will require a central focus on island-wide resights and recaptures. We have taken this into account in planning for 2017, and anticipate that future efforts will yield a robust dataset to estimate cohort size and age-dependent survivorship, these data will be extremely valuable in identifying critical life stages at which attrition is outpacing recruitment. Furthermore, plans are in development to carry out radio tracking of hatchlings in August and September 2017 to directly estimate survival probability and assess patterns of natal dispersal and habitat use.

While the multitude of activities that were successfully carried out in 2016 propelled us a large step forward in our long-term goals for the project, some factors arose that prevented us from doing more. One additional difficulty we encountered this summer was in actualising our plans for a concerted feral cat eradication effort in September 2016. Unfortunately, even in our partnership with the Cayman Islands Department of Environment (DoE) we were unable to rally the cooperation of all necessary government entities in advance of our field season. In the future, we are better equipped to foresee the logistical and financial challenges of such an effort although we still rely heavily on DoE support to help us navigate domestic policies on feral cat capture and euthanasia.

3. Briefly describe the three most important outcomes of your project.

Nesting ecology

The first major outcome of our nesting ecology research this summer was to identify aspects of SIRI behavioural ecology, including nest site fidelity and microhabitat selection, that direct habitat usage and maintain healthy levels of population recruitment on Little Cayman. Indeed, radiotracking and mark-recapture efforts made possible by the combined contribution of multiple funding sources in May and June 2016 revealed a broad distribution of home territories of females utilising communal sites as well as a high degree (>60%) of annual return rates among recaptured nesters. Preference for nest re-entry among subsequently nesting females at communal sites combined with strong philopatric tendencies result in significant spatial clustering and highly variable nest plans, and individual effort required for successful nest construction may be reduced by such tendencies. Meanwhile, hatchling SIRI appear robust across the entire observed range of nest conditions in our sample, including egg chamber depth and temperature regime as

well as close neighbour nest proximity. Minimal detected attrition in egg success over the course of incubation combined with a significant positive correlation between female snout-vent length and percent egg failure suggests that egg failure may be largely attributed to reproductive senescence in older females, rather than environmental circumstances. Our snake count data supports that high nest densities attract higher densities of native predators. However, we did not find any significant synchronisation of emergences among communal nests to suggest communal responses to this elevated risk. Nevertheless, high nest clustering may still generate favourable conditions for individual hatchlings simply by increasing the likelihood of predator satiation. Certainly the largest contribution of hatchlings in this study came from the protected communal nesting area, Preston Bay, where we estimate that *at least* 200 hatchlings successfully emerged over the course of 6 weeks.

Growth and dispersal

Secondly, our mark-recapture efforts over the course of only 2 years have yielded a wealth of data for estimating SIRI's growth and dispersal patterns within the first crucial years. Based on 1-year growth data obtained from small samples of hatchlings and juveniles, we can deduce that SIRI reach sexual maturity in 2 to 3 years (SVL=28-30 cm) and that the highest rate of growth occurs in the second year. The 1st year is characterised by the most variable growth rates, during which significant selection may result in a skewed size distribution. Our preliminary data also suggests that juveniles are very long-distance dispersers. Of the three 2015 hatchlings that we recaptured, all appeared to have established themselves in new locations after one year. One was discovered 14.9 km from its natal site, indicating that hatchlings are more than capable of traversing the length of the island. Re-sight data from days following hatchling release indicate that these long-distance natal movements may occur in short bursts. For example, in 20 such instances in 2015 and 2016, hatchlings were sighted between 0.006 and 3.1 km from their natal sites within one month of hatching. One hatchling in 2015 was re-sighted 2.96 km from its natal site after only a single day. Such observations suggest that long-distance natal dispersal may play a key role in population admixture on Little Cayman.

Population genetics

A third important outcome of our efforts this summer was the genetic sampling of over 400 hatchlings and 25 known mothers. These blood samples will be utilised over the next year to assign parentage to progeny arrays and to detect mixed clutches. Polyandrous mating, which occurs in a wide variety of taxa including *Cyclura*, has been postulated as a strategy to ensure the benefit of 'good genes,' or optimised outbreeding when females cannot distinguish close kin (Petrie *et al*. 1992). Highly promiscuous lizards (sand lizards and *Anolis*, which are 65% and 80% polyandrous, respectively) have been found to experience higher genetic diversity and viability

among progeny of multiple copulations (Olsson *et al*. 1994, Calsbeek *et al*. 2007). Cryptic female choice and sperm competition may also have a role to play in systems where pre-copulatory female choice is limited, as in female sand lizards selecting for sperm of distantly related males to sire their progeny (Olsson *et al*. 1996). Preliminary evidence from analysis of 2015 genetic samples provides strong indications that polyandrous mating occurs in SIRI, however, improved sampling efforts and female clutch matching in 2016 are expected to greatly increase resolution of these patterns, including the rate at which polyandry occurs and whether paternal skew favours males of more distant relation. Our ability to predict inbreeding effects in this small population and assess the degree of management needed will depend on a better understanding of potential behavioural responses and the genetic benefits they confer.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Throughout the course of this project we have maintained a close partnership with the Cayman Islands Department of Environment (DoE). This government body continues to provide invaluable support for our research in the form of on-island accommodation and transportation and part-time staff support, most notably by two members of DoE's Terrestrial Resources Unit, Jessica Harvey and Jane Haakonsson. In turn, our team provides the DoE with regular field reports and informed recommendations. Moreover, we continue to work with the DoE to coordinate concerted feral cat eradication efforts on Little Cayman, as obtaining euthanasia authorisation will require cooperation of multiple government departments.

Involvement and awareness among the local community also continues to be an important aspect of our work. Over the two years our team has been conducting research on SIRI, Little Cayman's small (<200) but passionate community has become increasingly involved and integral to our efforts. Our relationship of open communication with the Little Cayman National Trust, which we have maintained by attending regular meetings and exchanging updates with board members on research and monitoring data, has most certainly elevated our conservation impact factor on the island. For example, we have been invited to discuss important land prioritization and conservation measures with board members and to display a poster featuring our research in the Trust headquarters.

We have developed an especially close working relationship with two trust members, Michael Vallee and Ed Houlcroft, who founded the local programme, "Green Iguana B'Gonna." This fundraiser-supported campaign is aimed at enforcing biosecurity on the island and eradicating invasive green iguanas by raising local

awareness. As full-time dive instructors, Mike and Ed rely heavily on reports and accept any assistance available when it comes to locating and capturing animals. In fact, our team was directly involved in capturing three putative SIRI/green hybrids at the end of our field season in 2016 (see question 11). Mike also volunteered previously for Durrell's SIRI research team led by Matt Goetz (2007-11), and so maintains an intimate knowledge of local iguanas and has been monitoring annual roadkills since he moved to the island in 2008. Close collaboration throughout our field season, for example exchanging roadkill, nesting and green iguana sightings, has therefore been very beneficial to long-term monitoring and conservation efforts.

5. Are there any plans to continue this work?

Yes, we intend to continue our field efforts in 2017. In particular, we hope to begin expanding our research to SIRI's sister population on Cayman Brac as well as to conduct radiotracking of hatchlings on Little Cayman to achieve direct estimates of survival rates and patterns of dispersal in the first weeks. Meanwhile, our population monitoring efforts will continue via intensified mark-recaptures and expansion of nest survey areas. Ideally, return trips will also present opportunities to contribute to important conservation action on Little Cayman, including the eradication of feral cats and invasive green iguanas.

6. How do you plan to share the results of your work with others?

The results of our research have been shared and will be shared among the scientific community in the form of poster and oral presentations at annual meetings, including the IUCN SSC Iguana Specialist Group meeting and the Southeastern Population Ecology and Evolutionary Genetics meeting. Manuscripts are in preparation for publication in scientific journals. Additionally, our work has been shared with local partner organizations in the form of formal reports and posters. Growing media interest in our research has resulted in several articles, including a piece in the *Cayman Compass* published in July 2016 and a number of articles in local and international news outlets, including the Associated Press, covering the hybrid discovery in August. We remain open to and anticipate greater media coverage of our research over the coming months and years.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

This Rufford Foundation grant funded activities from August to early September 2016, during which fieldwork was ongoing.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Travel				
1 Airfare to Little Cayman (JM)	610	654	-44	
1 Airfare to Little Cayman (GG)	680	660	20	
1 Airfare to Little Cayman (JL)	610	0	610	Veterinarian, June Long was unable to travel to LC in 2016 due to personal conflicts.
1 Airfare to Little Cayman (TO)	55	0	55	Caymanian field assistant, TayVanis Oyog, was unable to return to LC in 2016 due to commitments with his American University.
Rental Car for 12 days @ 500 + 50/week fuel	600	0	600	Few DoE-supported research teams travelled to LC in August, rendering a part-time rental car unnecessary.
Travel Insurance	0	100	-100	
Equipment & Supplies				
Capture & Processing Supplies (noose poles, PIT tags, etc.)	1080	1570	-490	Reallocation of funds allowed us to purchase additional enclosure material for capturing hatchlings.
Blood sampling supplies (needles, syringes, and cryovials)	340	675	-335	Reallocation of funds allowed us to purchase additional supplies for genetic sampling of hatchlings.
Genetic Fragment Analysis	0	400	-400	Reallocation of funds allowed us to cover some costs of genetic analysis services upon return from the field.
Cat Stomach Sampling Supplies	340	0	340	Planned cat trapping efforts were not possible in 2016 as the cooperation of all relevant

				government entities was not secured in advance of the trip.
Other				
Food for 6 weeks @110/wk	660	900	-240	Reallocation of funds allowed us to recruit additional crewmembers to intensify field efforts.
Total	4975	4959	16	

9. Looking ahead, what do you feel are the important next steps?

Our first priority is analysing genetic samples collected in 2016 to quantify the effects of inbreeding and estimate rates of polyandry in the population. Looking ahead to 2017, we are developing plans for radio-tracking hatchlings. That study would characterise natal dispersal patterns and major sources of neonate mortality. In addition, we hope to make a couple of short sampling trips to Cayman Brac in 2017 to conduct a comparative investigation of inbreeding depression between the populations and lay the framework for a possible expansion of nesting studies to the sister island. We are also pushing for more serious consideration of feral cat eradication efforts on the islands.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

The Rufford Foundation logo was used in two posters: one displayed in the Little Cayman National Trust headquarters and another presented at the Southeastern Population Ecology and Evolutionary Genetics meeting in 2016. Rufford also received publicity in an article published in the *Cayman Compass* in July 2016 entitled "Shedding light on Little Cayman's iguanas."

11. Any other comments?

While completing hatchling surveys in August 2016, our research team was involved in the capture of three putative SIRI/green iguana hybrids on the West End of Little Cayman. The discovery of these hybrids was only possible because of heightened community awareness of the island's green iguana invasion threat, for which the founders of a local programme known as "Green Iguana B'Gonna" are largely responsible. Michael Vallee and Ed Houlcroft, two full-time dive instructors and Little Cayman National Trust members, have been volunteering their time to the eradication of invasive green iguanas since 2012 and have been extremely successful in getting the word out. With cooperation from the public, the team has

been diligently removing all reported green iguanas in an attempt to prevent their establishment on Little Cayman. The first hybrid hatchling was seen by a fellow dive instructor, immediately reported to Mike and Ed, and captured by them within minutes of receiving the phone call. Alerted to the threat, our research team captured two more hatchlings near the capture site of the first hatchling a few days later. Our joint appraisal of the hatchlings in consultation with the Cayman Islands Department of Environment leads us to the preliminary conclusion that a cross-breeding event has occurred between SIRI and an invasive *Iguana iguana*. On-going genetic analyses at Mississippi State University have confirmed the maternal identity of the hatchlings to be *Iguana iguana*, and common SIRI alleles have been detected at multiple nuclear loci.

Because the possibility of interbreeding between *Cyclura* and *Iguana* was not previously recognised, this discovery prompts new concerns over biosecurity in the Cayman Islands. The implication behind a cross-breeding event taking place on Little Cayman is that invasive iguanas are reaching breeding age and beginning to establish themselves on the island. If Grand Cayman is any example, once a population of green iguanas becomes established it is impossible to eradicate. Indeed, the suspected current population size of green iguanas on Grand Cayman is estimated to be in the hundreds of thousands. Intensified culling over the next few years may succeed in reducing these numbers, although under suspected population growth rates, total eradication seems unlikely. As long as green iguanas maintain a presence on Grand Cayman, they will also continue to be a source for future invasions of the Sister Islands. This is why it is crucial that local governments invest in adequate biosecurity measures to protect islands where green iguanas are not yet established and where endemic iguana populations are still relatively healthy.

While the struggle with greens is on going, Little Cayman is setting the stage for invasive species management on the local level. Community involvement and awareness plays a key role in controlling the spread of invasives on the island. However, this discovery emphasises the need for heightened biosecurity measures beginning at source populations. The Cayman Islands are mobilized on this front as well, with Grand Cayman significantly stepping up its green iguana culling efforts over the past couple of years. Because opportunities for human-mediated exchange between islands are only going to increase in the future, formulating a plan for long-term invasive species management will require a concerted effort by many Caribbean nations.


PRESTON BAY
IGUANA NESTING SANCTUARY