

**MSc Conservation Science**

**‘Assessing the Translocation of the St Lucia Whiptail Lizard  
*Cnemidophorus vanzoi*: A Retrospective Analysis of  
Abundance, Demographics and Habitat Utilization’**



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**A thesis submitted in partial fulfilment of the requirements for the degree of  
Master of Science and the Diploma of Imperial College London**

## **Abstract**

The St. Lucia whiptail lizard *C. vanzoi* is a ground dwelling, diurnal, primarily insectivorous macroteiid and a small island endemic. Originally it was only found on two islands (Maria Major and Maria Minor) off the coast of St. Lucia, West Indies. In 1995 due to perceived risk from the mainland a small population was translocated to the smaller uninhabited island of Praslin on the same coastline. In accordance with critics' views on the long term monitoring of translocated populations, I studied the abundance, demography, morphometrics and habitat utilization of the translocated lizard population over a 3 month period, 13 years post release. Not only was I analysing data collected in this study but also the data collected from previous monitoring studies in a time series analysis, in order to identify how the population has fared since the original translocation. Age, sex, snout-vent length (SVL), body mass (BM) and overall condition (moulting, gravid, cuts, parasites) of 100 lizards caught during the study were analysed and compared with the previous data. Body Condition (CI (BM/SVL)), age ratio (adult: juvenile), sex ratio (male: female) were also calculated and compared under the time series analysis. Distance sampling and mark re-sight surveys were used, calculating a mean abundance of 183 (95% CI: 132 – 279). Habitat utilisation was tested to identify if lizards select habitat randomly and also split by age and sex group. Overall since the translocation took place there appears to be no significant change in abundance, sex ratio, BM and CI. However the age ratio has changed, the number of juveniles to males had decreased suggesting there were problems potentially with juvenile mortality but this threat appears to have now passed. Juvenile mortality could also explain the significant decrease in adult female SVL and this should continue to be monitored. Lizards appear to select habitat non-randomly, choosing areas that help regulate thermoregulation. Overall, the study suggests that the population has successfully colonised Praslin Island, producing a self sustaining viable population.

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## 1. Introduction

Biodiversity is the very basis for the survival of all living organisms on earth, encompassing all life forms, ecosystems and ecological processes, acknowledging the hierarchies at genetic, taxon and ecosystem levels. Estimates of the total number of species on earth vary from 5 – 50 million; though 13.6 million is a more conservative figure (McNeely *et al*, 1990). However research has indicated that we are entering into a new phase of mass extinction (Myers, 1990). While previous extinctions have happened over millions of years the current mass extinction could well occur within a short period of time; within 200 years. Current scenarios predict a 20% loss of all species within the next 30 years and 50% or more by the end of the 21<sup>st</sup> century (Singh, 2002).

Conservation projects have become common place in the world, striving to preserve Biodiversity and halt continuing declines. Conservation scientists have thus been attempting to incorporate a wide range of management techniques to reduce this decline in Biodiversity. In the face of this global biodiversity crisis translocation has become an important conservation technique. Translocation is defined as the intentional release of animals to the wild to establish, re-establish, or augment a population (IUCN, 1987). Species translocations can form a valuable part of a species recovery programme, which is aimed mainly at reversing historical declines or increasing limited ranges sizes in the status of species of conservation significance. However, the role of translocations in conserving species is a matter of debate, with a range of views within the statutory conservation agencies (and elsewhere) on when and where such activities are acceptable and desirable.

Although species translocation has become a popular tool, several previous studies have suggested that many relocations are not successful and fail to achieve self sustaining populations (Griffith *et al*, 1989; Dodd and Seigel, 1991; Lindburg, 1992; Wolf *et al*, 1996; Fischer *et al*, 2000) and thus have given rise to increased scientific speculation as to what factors influence the success or failure of translocations.

Like so many other conservation practices, translocations are often ad-hoc decisions made in crisis situations, without clear defined objectives, methodologies, measures of success and long term follow up studies, which are all indications of a project that is likely to fail (Dodd and Seigel, 1991). A recent survey carried out by Fischer *et al* (2000) on the assessment of animal relocations found that only 26% of reintroductions could be classified as a complete success. However this number is likely to be over estimated due to the study only being carried out on published results and often projects will only publish their results if they have been successful.

Despite countless articles highlighting problems concerning species translocations and how they can be addressed (Dodd and Seigel, 1991; Fischer *et al*, 2000); and regardless of the many variables which influence the success of a translocation not all translocation programmes evaluate those factors, nor are they carefully monitored (Cabezas *et al*, 2007). To ensure that any translocation efforts are going to be as successful as they can be, it is essential they follow through with the recommendations.

One of the main recommendations, which relates to this study, is the long term monitoring of the species once it has been translocated (Dodd and Seigel, 1991; Fischer *et al*, 2000). Monitoring should be carried out on a long term basis because success can take a long time to confirm, especially if a species has a slow reproductive life history. A lot of studies have failed to follow a strict population monitoring scheme (Fisher *et al*, 2000), and it has been suggested that wildlife managers should develop long term monitoring protocols in which key parameters that can reflect success are carried out at specified time intervals. These parameters can be abundance, sex and age ratios to name but a few. Secondly is the importance of sharing information about translocations (Fischer *et al*, 2000) - not just regarding successes but also the failures, so other projects can use the information to see what has worked, but more importantly, what hasn't.

## **1.1 This Study**

The St. Lucian whiptail lizard *Cnemidophorus vanzoi* is of particular conservation concern, a sole island endemic restricted originally to two small offshore islets off the

coast of St. Lucia, Maria Major and Maria Minor. Due to low population numbers, its unique taxonomic status, restricted range and perceived threats related to the islands' proximity to the mainland (i.e. introduced predators) and an inability to establish an ex-situ population, translocation was a priority for this species (unpublished data). The translocation took place in 1995 run by the Jersey Wildlife Preservation Trust and the St. Lucia Forestry Department. Originally 39 individuals were translocated to nearby 1.1ha Praslin Island, however a lone Indian mongoose (*Herpestes auro punctatus*), which was on the island, destroyed 25 of the mature whiptails. After the removal of the mongoose seven more pairs were translocated and these formed the founding stock of today's population on Praslin Island.

The Praslin Island population has been monitored quite regularly since its translocation in 1995 and the data collected had indicated that the population was viable and self sustaining.

I propose to gain more insight into how the population has fared since the first individuals arrived back in 1995, by incorporating monitoring data that I have collected from this study, with data collected on previous monitoring occasions and running a time series analysis on various variables of the whiptail lizards to test for significant associations (population trends, age and sex ratio trends, condition index trends, snout – vent – length trends and body mass trends). I will also be looking to identify specific habitat requirements (i.e. is habitat selected randomly) associated with the lizards and how this may relate to population morphometrics. The data generated from this study will not only help determine the success status of the translocation of the St. Lucia Whiptail Lizard to Praslin Island, but also provide additional data regarding this species, which can be used by Jersey Wildlife Preservation Trust and the St. Lucia Forestry Department in the plans for future translocations of this species to other Islets off the coast of St. Lucia.

This study will also examine different sampling methods for population estimates, distance sampling (Laake *et al*, 1992) and PETERSONS (krebs, 1989) mark re- sight.

## 1.2 Objective

This study was undertaken to assess the population of the translocated whiptails on Praslin Island, to provide data to identify if the translocation effort has been successful and to identify any factors that may effect future translocations of this species as well as identifying any specific habitat characteristics of this species.

In this study I will therefore address:

- What is the current population estimate for the Praslin Island lizards?
- Do different sampling methods give similar population estimates?
- What has been the population trend for Praslin Island lizards since 1995?
- What has been the demographic trend for Praslin Island lizards since 1995?
- What has been the morphometric trend for Praslin Island lizards since 1995?
- Are the lizards selecting habitat randomly?
- Can this translocation be classed as a success?

## **2. Background**

It has been said on many occasions that animal translocation is an increasingly important management tool used to promote the chances of species survival (Tasse, 1989). To date few translocations have been seen as successful. Further more it has been suggested by critics that most translocations suffer from poor documentation, lack of external evaluation and peer review, as well as monitoring inadequacies (Dodd and Seigel, 1991; Miller et al, 1991; Fischer and Lindenmayer, 2000). I will review two main papers which claim to be able to contribute to the development of a better understanding of the problems facing translocations. I will then move on to review the use of small islands in species translocations, and finish by reviewing previous published data on the translocation of St. Lucia whiptail lizards (*Cnemidophorus vanzoi*).

### **2.1 Assessment of translocations**

Fischer and Lindenmayer (2000) published a paper in biological conservation named 'An assessment of the published results of animal relocations'. In this paper they review 180 case studies of animal relocations from the results published in 12 major international scientific journals focusing on reintroductions, supplementations and translocations. Many cases failed to be classified as successful, due mainly to lack of supporting criteria to do so. They also reported that only 3% of the papers documented the cost in their publications. They also suggest that the value of relocations can be enhanced greatly by following the following recommendations: (1) more thorough testing for appropriateness of the approach in each case, (2) the establishment of widely used and generally accepted criteria for judging success or failure, (3) better monitoring after relocation, (4) better financial accountability and (5) greater effort to publish results even if the relocation has been unsuccessful.

Fischer and Lindenmayer (2000) employed the new approach of searching peer review journals, rather than using mailing surveys to explore the success of translocations. Detailed literature searches have the disadvantage that sample cases

could well be several years older than if mail surveys were used and may only be a subset of all relocations, as many are never formally published. However because of the abundant number of published cases of animal relocations available, this seemed like the best approach, and it would form suitable baseline data for many conservation biologists and wildlife managers. They aimed to answer broader questions than those that had been asked previously in older mail surveys and then compare and contrast the results. Fischer and Lindenmayer (2000) did not perform statistical analysis on the results as they deemed it inappropriate, as models may overestimate their chances of success when extrapolated to different environmental conditions, instead choosing to illustrate the more prevalent trends apparent in their data.

Fischer and Lindenmayer (2000) stated that although the results of the study did not reveal particularly high success rates, they believed their findings still to be an overestimate of reintroduction success, due to the fact that authors are less likely to publish results of failed reintroductions, as also applies to mail surveys (Reading *et al*, 1997). They decided that this fact in combination with the large number of ‘uncertain’ data made it relatively difficult to draw general conclusions, however they did manage to identify several factors, which can enhance the success of relocations.

Fischer and Lindermyer (2000) concluded that relocations are a common, popular and potentially powerful tool in conservation. However most are poorly carried out in an ad hoc fashion and are not properly monitored. Combining this with the fact that most translocations are poorly documented, they state that translocations have much to learn from following a few simple steps to ensure that conservation funds are spent in a more efficient manor.

After carefully considering all the points made by Fischer and Lindermyer (2001) I believe their paper to have strong arguments, especially regarding future recommendations for translocation programmes. However I am of the opinion that to produce clearer guidelines to help define success or failure will be hard to incorporate into one general document. Each translocation is unique; many factors will contribute to the success or failure. You cannot generalise one species against another and you must consider that similar species can and often will have totally different life histories which need to be taken into account. Some species have faster reproductive

capabilities than others, which is why all data should be published regardless of success or failure. The method used by Fischer and Lindermayan (2001) to review relocations is interesting and provides some interesting results. I agree that statistical analysis should not have been carried out because this could have led to some confusing results, and that the review itself gave enough insight into patterns of the relocations. I can't, however, help but wonder if by combining the literature survey with a mail survey they could have provided even better results.

In comparison Dodd and Seigel (1991) carried out an extensive review entitled 'Relocation, Repatriation and Translocation of amphibians and reptiles: are they conservation strategies that work? The study forms the basis on which recent reviews on endangered birds and animals showed low success rates. With a number of relocation, repatriation and translocations (RRT's) carried out, underway or advocated for amphibians and reptiles, data was examined for motives for advocating RRT strategies and recommendations made that should be considered prior to undertaking RRT projects. They confirm that many RRT's involving amphibians and reptiles have not demonstrated success as a conservation technique. They urge caution in accepting claims of success and urge studies to be published both past and present.

Dodd and Seigel (1991) carried out an extensive literature search documenting 25 RRT programmes that had been carried out on amphibians and reptiles using Griffith *et al* (1989) in defining a RRT as successful only if evidence is presented that a self sustaining population had been established. The review is based upon published references in open literature, unpublished references and personal communications, and acknowledges the fact that some RRT's may have been missed whose results remain unpublished.

Dodd and Seigel (1991) identified in their study that in some circumstances avocation for RRT programmes were based on limited success in a few species and strongly disagree with this approach stating it to be naive and ill informed. Their greatest concern however was the premature claim of success, which should not be stated until long term monitoring can give credence to success. In their view the lack of information is a major contributor to failures and that data is hard to come by. They consider it essential that both positive and negative results be made available if

mistakes are to be avoided in the future. They also recommend the following to help increase success for future RRT programmes: know the cause of decline and know the habitat restraints of the species; understand population genetics and social structure and carry out long term monitoring.

Dodd and Seigel (1991) conclude that decision making in conservation is often made by non-scientists or under extreme crisis circumstances. However at the moment their results have cast doubts over the effectiveness of RRT programmes as a conservation strategy, in the most part for amphibians and reptiles. Unless commitment for the collection of baseline data, providing follow up studies and publication of results is available, translocations should be avoided and other conservation strategies should be considered.

The Dodd and Seigel (1991) review was based entirely on a literature review, a critical analysis of data available, however no figures were used to back up findings as done in Fischer and Lindermayers (2000) review. However the paper did provide a useful insight into RRT programmes aimed directly at amphibians and reptiles. The results were surprising, stating that out of 25 cases only 19 were classified as successful. This may be due to small sample sizes, however with a lot of translocations deemed unsuccessful it appears this figure could be on target, or as stated before, underestimated, due to the lack of published negative results. The paper had really strong views regarding what should and should not be done in advocating RRT programmes for amphibians and reptiles. Although I agree with most of the points made, I believe in some cases that translocation may very well be the last chance for a species survival and there simply just isn't time to discuss which action is the most appropriate as recommended by (Dodd and Seigel, 1991).

Both papers have given a really sound review on the process of translocations and the problems that encompass them. Although both papers focus on different inputs, it is interesting that both bring up the same recommendations. What would be interesting would be publishing the combined recommendations of translocation review papers in a document to aid future translocations. The main points that I have picked up from both papers is the need for adequate baseline data and long term monitoring. What I found particularly interesting, and what is often overlooked on many occasions is how

the species interacts with its environment. Post-release monitoring of translocated animals should not be just about survival but also the ensuing specie-habitat relationship – not just simply determining the number of survivors, but also interpreting the ensuing species–habitat relationships. Of particular importance I thought was the mention in Fischer and Lindermayens (2001) paper, about better financial accountability. I believe this can be a really useful tool to see how and where money has been spent so that in future funds can be spent more efficiently, which is extremely important in a science with limited funding. Finally and most importantly both papers picked up on the need to publish more data, whether positive or negative, both results are just as important as each other. The negative results, which often are not published, can help form the baseline of adaptive management in future projects. The stigma attached to unsuccessful translocations needs to be removed to ensure that translocation can fulfil its potential as a powerful tool.

## **2.2 Small Island reserves in Translocation**

A complementary approach to translocation, is the approach of translocating a species to islands where they formerly occurred, or the translocation of a species to islands where the threatening process is absent; otherwise known as marooning (Williams, 1977). The greatest developments of this technique is in New Zealand, where several bird and land bird species have been successfully translocated from areas threatened by sheep, mustelids, cats or rats to islands free of these threats (Serena, 1995). Abott (2000) discusses in his paper the use of island reserves for mammal conservation in Western Australia.

Abott (2000) reviews the islands of Western Australian, indicating which are free from exotic carnivores and which are not. Of 254 islands he deduces that between 147 and 122 islands offer potential as sites for future translocations. The islands are already thought to be of particular importance for conservation of terrestrial mammals, without them 4 species (Marl *Perameles bougainville*, Boodie *Bettongia lesueur*, Banded hare-wallaby *Lagorchestes fasciatus* and Djoongari *Pseudomys fieldi*), once occurring over large part of the Australian continent would now be extinct. In his paper Abott (2000) states that the advantage of transferring populations

of threatened species to islands is that ongoing management monitoring and management is minimal, relative to protecting populations on larger landmasses. He describes the methods of island selection and a number of factors that needed to be considered to ensure the island's suitability i.e. habitat and exotic predators, and also the methods of selecting the species for translocation to the island.

This short review provides details on how islands can be used in translocations, by providing safe havens for threatened species, that without the relatively safety of the island may possibly face extinction. Island selection is not necessarily easy as many factors must be considered, however the amount of time required to identify suitability obviously depends on the size of the island in question. I believe Abott (2000) makes a genuinely good point regarding management of these islands being minimal in comparison to mainland habitats but, this should be emphasised that constant management is still required i.e. monitoring. However island reserves can make a constructive addition to translocations.

### **2.3 Translocation of St. Lucia whiptail lizards (*Cnemidophorus vanzoi*)**

Dickinson and Fa (2000) were the first to publish their findings on the translocation of the St. Lucia whiptail *C. vanzoi* to Praslin Island. The study was carried out three years post release and undertook data collection on abundance, demographics and morphometrics across a 6 month period covering both wet and dry seasons. The study was carried out on 107 animals caught during the study. The study estimated a total population of  $155 \pm 26$  individuals. There were found to be significant seasonal fluctuations in lizard abundance that suggested severe resource limitations during the dry season, with high intra-specific competition found between individuals. The study deduced that individuals had successfully colonized Praslin and no significant change from the source population was identified.

Dickinson and Fa (2000) used methods of noosing to catch individuals from this study, made from 4.4kg breaking strain, monofilament line. Individuals were sexed using colouration and number of scales present above the vent as described by Vitt and Breitenbach (1993). Animals were weighed using a hand held spring balance. Abundance estimates were taken each month and estimated using DISTANCE

(Laake, 1994) and PETEREN (Krebs, 1989) mark re-capture. Estimates were given for each month and then calculated for each season as well as overall. Extensive statistics were carried out on the population to identify demographic and morphometric data with body condition calculated using a CI (condition index) scoring system.

Dicknson and Fa (2000) concluded that the St. Lucia whiptail *C. vanzoi* on Praslin Island followed the same life history traits as over tropical lizards, accommodating for resource fluctuations associated with distinct wet and dry seasons effecting CI and body mass. The mean population estimate for Praslin Island was higher than expected according to species area relationships. The study is claimed to provide a useful insight into the translocation of a relatively unknown species, providing baseline data for future monitoring and resulting in the increased survival potential for the species by reducing extinction risk. It was concluded that no significant change in the population's body mass or condition index had occurred since translocation and that the founder population had successfully populated Praslin Island in 3 years and was reproducing successfully in its new environment.

The paper provides a really good introduction to a relatively unstudied species, providing extensive baseline data for future monitoring projects to work from. The results of the study were clearly presented with sound statistical analysis covering a wide array of variables. The study was also supported by another publication Dickinson *et al* (2001) providing useful insight into the micro habitat use of this species. Together, these papers provide a detailed, thorough analysis of the translocation three years post release. The only piece of evidence I find a little outdated is the use of snout-vent-lengths in calculating the adult status of the female. The measurement is taken from an average of all *Cnemidophorus* species; however body size can vary greatly through this genus. Young *et al* (2006) details the significant body sizes of *C. vanzoi* found on Maria Minor (the original source population) against those found a few hundred meters away on Maria Minor, thus how can this figure be interpreted accurately? I can't help thinking that the method may need to be updated at some point in the future, especially if individuals from Maria Minor are used to supplement translocations in the future. I believe that although the paper points to early success, three years post release is too short a time

to make any substantial conclusions. The data shows a positive trend, which should be taken as a good starting point however I believe that the translocation should be monitored for a few more years before any definitive answer can be made. Environmental variation and demographic stochasticity in particular impact small populations in the short term and thus the population should be managed with this in mind. However, overall, the paper provides a really useful insight into the translocation and the post release phase of this species, indicating promising results.

### 3. Methods

#### 3.1 Study species

The *Cnemidophorus* lizards are a complex genus belonging to the family teiidae, made up of both bisexual and parthenogenic species, with their geographic range spanning from Southern North America to central Argentina (Wright & Vitt, 1993). The St. Lucia Whiptail (*C. vanzoi*) belongs to the group *Cnemidophorus lemniscatus*, and is one of the least studied groups and also most primitive like, thus it has been suggested that all other North American groups may have derived from this group (Wright & Vitt, 1993).

*C. vanzoi* is a ground dwelling, diurnal, primarily insectivorous macroteiid (Vitt & Breitenbach, 1993). The species is sexually dimorphic, males which often are double the size of females have sulphur yellow ventral surfaces, with a turquoise tail and flank. Females, smaller than the males are predominantly brown with a cream ventral surface, fig(1).

**Fig1.** The male (A) and female (B) *Cnemidophorus vanzoi* found on Praslin Island, St Lucia.

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They appear to thrive in shrubby habitats and in mixed woodland with access to open grass areas and rocky outcrops, such as that on Maria Major. The species may climb thick stems or vines in shrub or woodland habitat, although most of their time is spent

foraging on the ground. During foraging the lizards will scratch in the soil surface and leaf litter where it feeds upon termites, scorpions, carrion and fruit of *Fiscus citrifolia* (Schwartz & Henderson, 1991). It is the sole representative of its genus in the Lesser Antilles and a single island endemic to St. Lucia (Schwartz & Henderson, 1991) and it is listed as vulnerable under the IUCN Red List (IUCN 2006). No evidence has been found of this species ever having been present on mainland St. Lucia, but it is thought that this is the case. The lizard originally inhabited two small offshore islands (Maria Major and Maria Minor) before the translocation in 1995, however due to perceived risk from fires, introduced predators and to increase the species distribution, Jersey Wildlife Preservation Trust and the St. Lucia Forestry Department translocated lizards from Maria Major to Praslin Island.

### 3.2 The study Site

Praslin Island is situated off the Eastern coast of St. Lucia (13852.2'N, 60853.1'W). It lies in the mouth of sheltered Praslin Bay and is located 220m off the coast of the mainland and has an approximate area of 1.1ha, fig(2). Praslin is a privately owned island, which is leased to the St. Lucia forestry department for the conservation of the St. Lucia Whiptail.

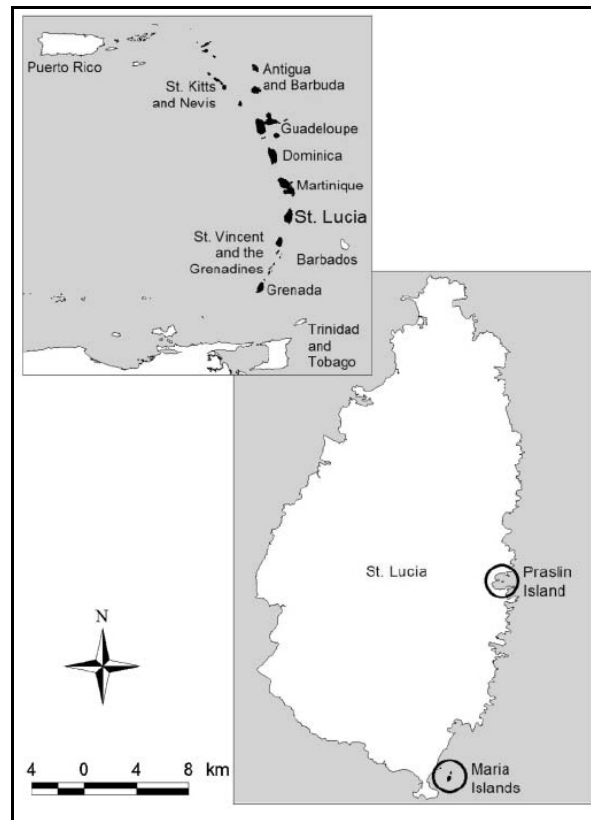
The vegetation has recovered since the removal of goats in 1991 and further still since the eradication of rats in March 1993 (Johnston *et al*, 1994).

The region has a distinct climate with the wet season running from June through to December and the dry season running from January through to May. During the months of August and September hurricanes and tropical storms are a minor threat to the island (Applied Technology & Management Inc., 1996).

Praslin is covered by 5 main habitat types: (1) mixed wood, (2) manchineel woodland, (3) scrub, (4) bunch grassland and (5) mixed grassland (for the sake of this study bunch and mixed grassland were pooled together into 'grass', due to low sample sizes in each habitat, to give 4 main habitat types. The canopy layer consists of *Pithecellobium unguis-cati*, *Tabebuia heterophylla* and *Cornutia pyramidata*. Shrub dominated by *Rauvolfia viridis*, with herb vegetation comprising of *Spermacoce ernestii*, *S. verticillata* and *Ruellia tuberosa*. The manchineel woodland in comparison consists of *Hippomane manchielle* trees and a sparse shrub layer or *R. viridis* and *Tabernaemontana citrifolia* with little if any herb layer. There are numerous

Bromeliads *Tillandsia utriculata*, and grasses being made up from *Schizachyrium microstachyum*, *Cyperus sphacelatus*, *Fibristylis ovata* and *Digitaria sp.*

**Fig2.** Map of St. Lucia, showing Praslin Island where this study was undertaken and also the Maria islands, the source of the translocated population (Young *et al.*, 2006).



### 3.3 Abundance Estimates

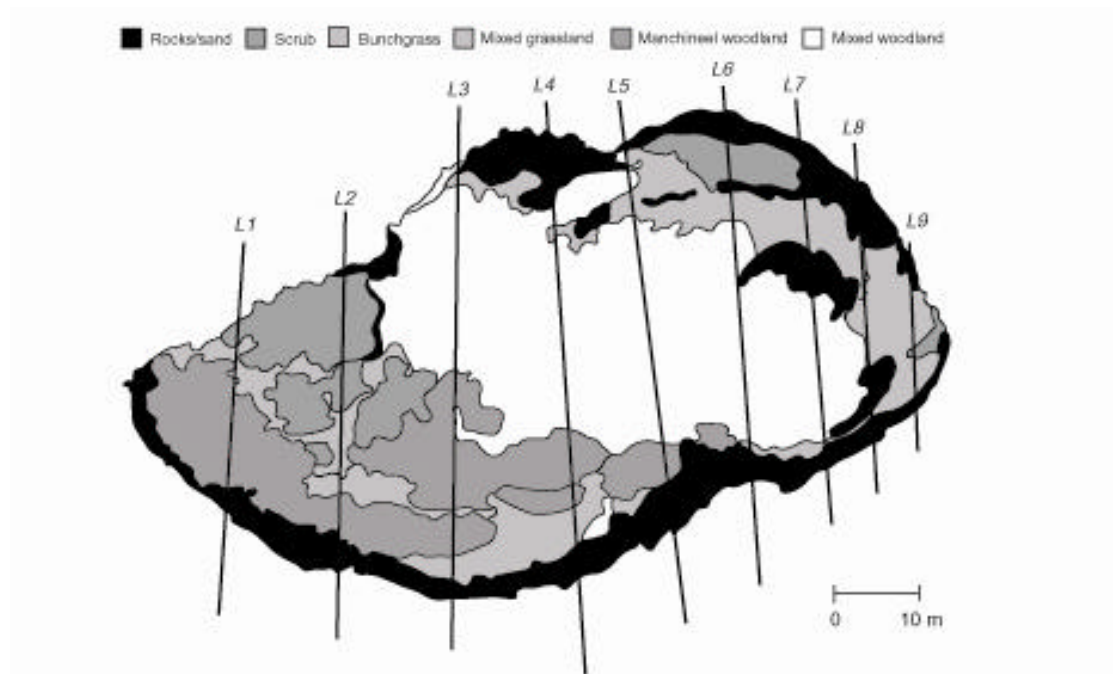
This research was conducted from May – July 2008, two methods for population estimates were used in this study; distance sampling, an extension of finite population Sampling (Buckland *et al.*, 1996) and PETERSEN mark re-sight survey consisting of one mark and one re-sight event (Krebs, 1989).

Methods to estimate population abundance using distance followed closely to those described by Dickinson & Fa (2000), with minor modifications. 9 transect lines were marked, spaced 20m apart, following a bearing of 307°N, with total transect line distance being 295m, fig(3). Transects were walked only if it was sunny, once or twice per day between 10am and 2pm to coincide with peak lizard activity. When a lizard was sighted its location was marked with a numbered stick, and age and sex was recorded. Sex was estimated from colour, size and behaviour and individuals

were carefully identified for any distinguishing marks, and direction was also noted to ensure individuals were recorded only once per line. Lizards that had been disturbed while placing markers and not previously recorded were not recorded. Once transects had been walked, lines were re-walked and the exact location of the lizard was measured to the line to identify perpendicular distances.

Abundance was estimated from the data collected using DISTANCE 5.0 (Laake *et al*, 2006). DISTANCE models the decreases in detection as objects get further from the line, fitting a probability density function (pdf). Models used in this study were Hazard rate and Uniform (Simple polynomial and cosine adjustment functions) and Half normal (Cosine and hermite polynomial adjustment functions). All models were run with a truncation of the highest 5%, with models selected by Akaike's information Criterion, Chi-P value and percent coefficient of variation (Buckland *et al*, 1996).

**Fig3.** Map of Praslin Island showing similar transects walked during this study and island habitat characteristics (Dickinson & Fa, 2000).



For the PETERSEN estimate lizards were caught using a noose made of a length of 10lb fishing line attached to a light, flexible wooden pole approximately 1.5m in length. A lop was made with a slipknot, then lowered over the head of the

lizard and jerked tight (Simmons, 1987). Each lizard caught for morphometric measurements were individually marked with white nail varnish on the dorsal surface between the hind legs, using a combination of numbers and letters. Markings were retained for at least 1 week, with most observed peeling off by the end of the third week. This short duration of being marked reduces the likelihood of severe predatory and selection pressure. Resurveying of the lizards was carried out 5 days after first marking. Mark re-sight data was analysed using the PETERSEN, in Krebs (1989) equation:

$$N = \left[ \frac{(n_1 + 1)(n_2 + 1)}{m_2 + 1} \right] - 1$$

The following formula was then used to calculate 95 % confidence intervals:

$$W1, W2 = p \pm \left[ 1.96 \sqrt{\frac{p(1-p)(1-m_2/n_1)}{(n_2 - 1) + \frac{1}{2n_2}}} \right]$$

This method is assumed to be unbiased for small, closed populations and thus particularly suitable for sampling abundance on Praslin Island.

### 3.4 Morphometry and demography

The Praslin island lizard population was censused during June 2008, the beginning of the wet season (although at the time of capture the weather had been unusually dry). Lizards were caught (method described above) by hand held noose. Sex was determined by the number of scales found above the vent (male  $n = 3$ , female  $n > 3$ ). Adult males have a sulphur yellow ventral surface and turquoise tail and flank, thus age status of males was determined by colouration. Juvenile males and females are predominantly brown with cream ventral surfaces. To determine adult status of adult females a snout-vent-length (SVL)  $> 76$ mm was used as they display no secondary sexual characteristics. This measurement was described by Vitt & Breitenbach (1993) as an ‘average’ female *Cnemidophorus* based on a review of the literature of the genus. SVL, snout – ear, head width and tail length were recorded using 30cm ruler to the nearest mm. Lizard body mass (BM) was determined by placing the lizard in a cotton bag and weighing with a 100-g hand held spring balance

to the nearest gram. General condition of each lizard was noted including, moulting, gravid, cuts, parasites and tail damage.

Data was analysed by age-sex groups: adult male, adult female, juvenile male and juvenile female. Body size was tested by the four main habitats using ANOVA. Mean sex ratios (males: females) and age ratios (adults: juveniles) was calculated and a simple linear regression was performed. Condition Index (CI, length-correlated mass; Wilson, 1991) was calculated and pooled for the years 1999, 2002, 2005 and 2008 and was tested using ANCOVA. CI calculations did not include females expected to be gravid (Wilson, 1991). BM and SVL data were also pooled across all years and an ANCOVA test was performed on both sets of data.

### **3.5 Habitat utilization**

During June 2008 each habitat type was systematically searched for lizards, during the collection of morphometric data and where possible each lizard was caught. Eight microhabitat characteristics (Table.1) were recorded in a 3m<sup>2</sup> area around each point where the lizard was caught, generating 100 samples spread throughout the four habitat types. Microhabitat variables were split into three categories (1) substrate cover, (2) aerial cover and (3) thermal characteristics. Substrate cover was split into four main types and assessed visually, and was based on main substrate categories; ground vegetation (consisting of small grasses and plants, but did not include young woody shrubs), bare ground (consisting of soil only), bare rock (consisting of rocky substrate/rocks) and leaf litter. Aerial cover was determined by percent of canopy cover as well as percent of area covered by shrub and was visually assessed. Thermal characteristics were recorded by taking ground temperature where the lizard was caught and identifying amount of sunlight entering the area and was assessed into one of three categories (1) shade, (2) dappled or (3) full sun.

In order to identify if whether lizards were selecting habitat and microhabitat randomly, transects used for distance sampling were walked and every 15m random sites were determined by throwing a stick (within the size and weight range of the lizard) in a random direction. Then habitat variables were recorded as if recording for a lizard, as described by Pernetta *et al* (2005) giving a total of 30 random sites across Praslin Island. Analysis was carried out using general linear models.

**Table.1.** Description of the eight microhabitat characteristics within 3m<sup>2</sup> of all *Cnemidophorus vanzoi* in Praslin Island, June 2008.

<b>Microhabitat variable</b>	<b>Description</b>	<b>Categories or units</b>
<i>Substrate cover</i>		
Ground vegetation	Visually assessed	% 3m <sup>2</sup> area
Bare ground	Visually assessed	% 3m <sup>2</sup> area
Bare rock	Visually assessed	% 3m <sup>2</sup> area
Leaf Litter	Visually assessed	% 3m <sup>2</sup> area
<i>Aerial cover</i>		
Shrub	Visually assessed	% 3m <sup>2</sup> area
Canopy cover	Visually assessed	% 3m <sup>2</sup> area
<i>Thermal Characteristics</i>		
Ground Temperature	Recorded with thermometer	Degrees Celsius 1:Shaded, 2:Dappled sun, 3: Full sun
Amount of sunlight	Visually assessed	sun

Habitat utilisation data was also pooled into age and sex classes to identify if there was any selection between the sexes (male and female) and also between the different age classes (adult and juvenile) analysis was carried out again using general linear models.

### 3.6 Statistical analysis

Statistical analysis was carried out using the statistics programme R version 2.7.1. R is a language and environment programme for statistical computing and graphics, providing a variety of statistical and graphic techniques.

Population trend, sex and age ratio data were analysed using a simple linear regression. This particular test was used due to the fact that both the response variables and explanatory variables were all continuous, allowing a simple linear regression to be carried out. Due to such small sample sizes ( $n = 4$ ) the data could not be deemed not 'normal' and was assumed to be normal so linear regression was used.

Data analysis for body condition, SVL and BM pooled across all years was analysed using analysis of covariance or ANCOVA. These data sets had one continuous response variable, one continuous explanatory variable (year in all cases) and two categorical explanatory variables (age and sex). All data was tested for and proved to be deemed normal and therefore ANCOVA was used in these analyses.

A simple analysis of variance or ANOVA was used to test BM in each different habitat, the data was found to be normal and all the explanatory variables were categorical, enabling the use of ANOVA.

General linear models or GLM's were used to test whether lizards were selecting habitat randomly or not. The response variable was binary i.e. present (for habitat variables from caught lizards) or absent (for habitat variables from random sites). Thus the data followed a binomial distribution. There were several habitat variables that were then run with the model, mentioned previously.

## 4. Results

### 4.1 Abundance Estimates 2008

Density was estimated using *Distance 5.0*. A mean population size of 181 (95% confidence interval: 121 – 272) was estimated for Praslin Island from data collected during May and June 2008, Table (2) (see Appendix (A3) for detection probability graph).

**Table.2.** Abundance estimates of *Cnemidophorus vanzoi* in Praslin Island using *Distance 5.0* estimate

Number of clusters observed	Density (Lizards/ha)	Population (95% CI)	% CoV	Encounter rate (Lizards/ha)	Model
182	164.8	181 (121 - 272)	18.09	94.3	Uniform Cosine

Density estimated using PETERSON (Krebs, 1989) method for mark-resight gave a mean population size of 185 (95% CI: 142- 286) for Praslin Island from data collected during June 2008, Table (3).

**Table.3.** Abundance estimates of *Cnemidophorus vanzoi* in Praslin Island using PETERSON estimate

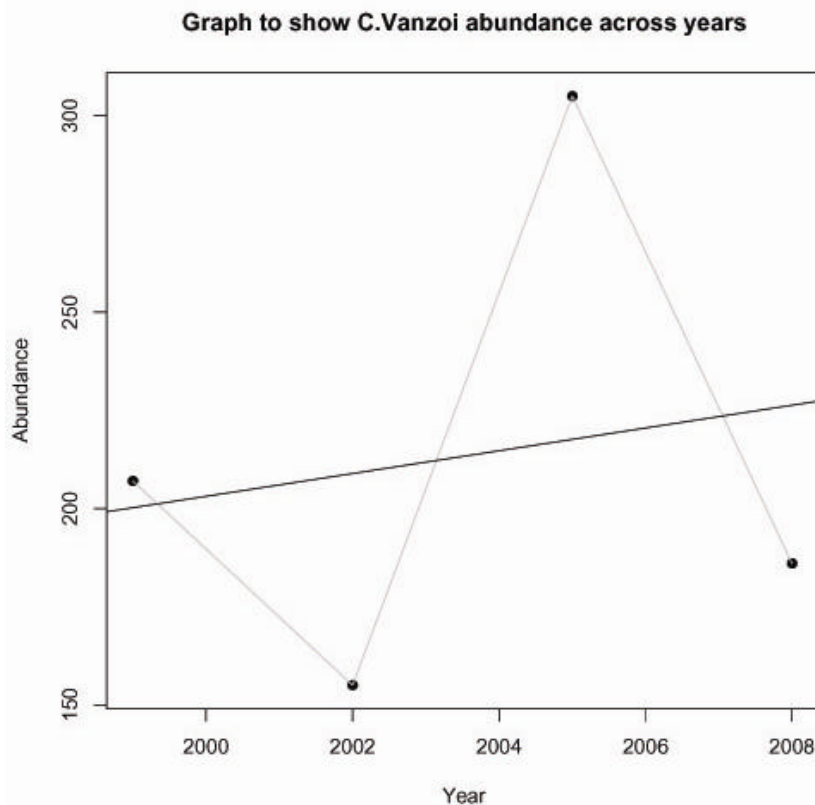
Number of individuals marked	Number of individuals re-sighted	Marked Re-sight	Density (Lizards/ha)	Population (95% CI)
73	38	16	168	185 (142 - 286)

Comparisons between *Distance* generated and PETERSON generated abundance estimates are very similar. Both estimates fall within 4 individuals of each other, with both showing relatively small confidence intervals. Mark re-sight surveys, however tend to only estimate the catchable population and thus may underestimate population abundance in comparison to *Distance*. However when a significant proportion of the population has been caught as in this study, the estimates give more reliable predictions. Thus for this particular study, abundance estimates produced by each method provided similar results. By taking a mean of the two sample sizes a population estimate of 183 (95% CI: 132 – 279) individuals for Praslin Island can be deemed.

## 4.2 Population trends

Abundance estimates for *Cnemidophorus vanzoi* on Praslin Island from 1999, 2002, 2005 and 2008 using *Distance* were collected from previous studies and tested to identify any significant change in population abundance over the years. The analysis failed to find any significant change in abundance between 1999 and 2008 (regression test,  $F= 0.06$ ,  $P = 0.8266$ ,  $d.f. = 2$ ). Therefore since the first set of data was collected in 1999 the Praslin Island population of whiptails has remained stable. However although the test showed stability in population size as a whole, the population has actually fluctuated quite a lot (fig 4). Data collected from 1999 estimated a population size of 207 individuals, however by the time the next population estimate had been carried out in 2002 numbers were estimated to have dropped to 155 individuals. 3 years later however during the next population estimate, the population has grown significantly and was estimated at 305 individuals. During this study undertaken in 2008 the population appeared to have decreased once again to an estimated 181 individuals. This result clearly shows that although the population is stable it is in fact subject to many fluctuations.

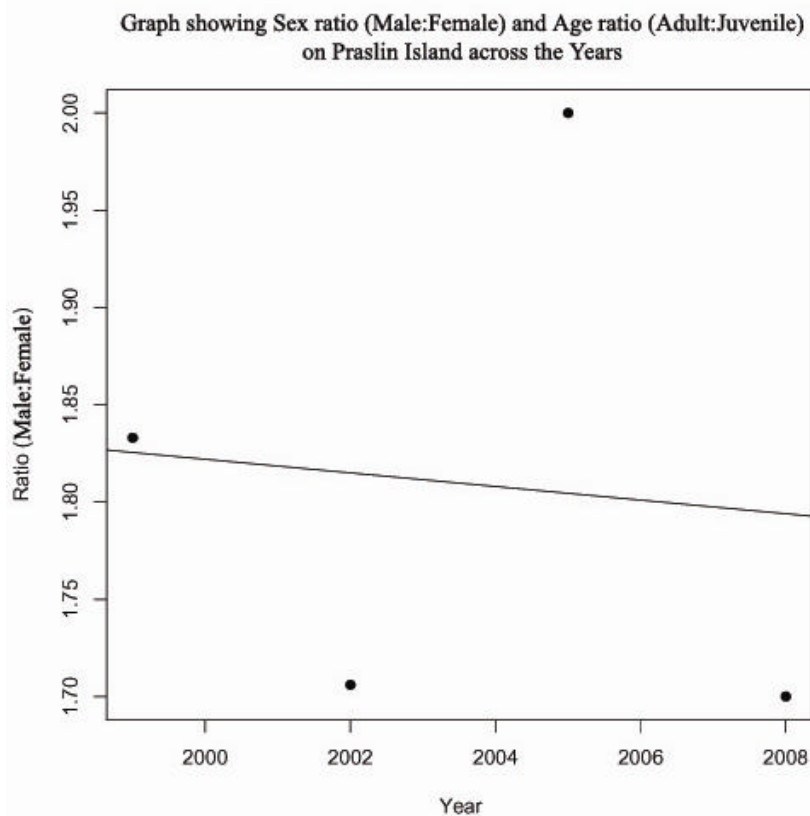
**Fig .4.** Abundance of *Cnemidophorus vanzoi* on Praslin Island 1999 to 2008.

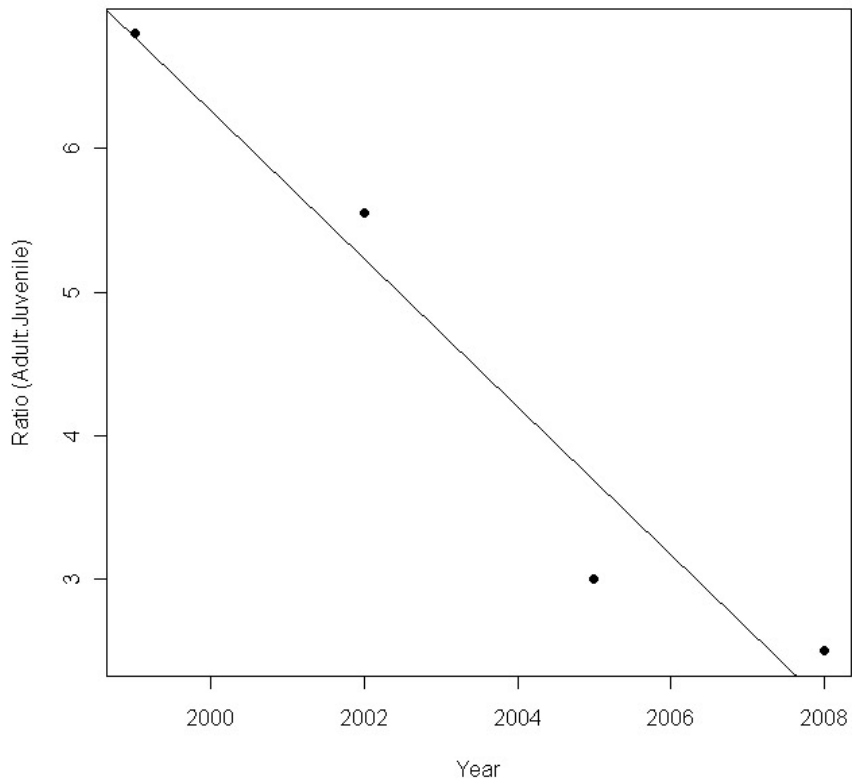


### 4.3 Demographics and dimorphism

The mean sex ratio and age ratio of individuals caught on Praslin Island for 2008 was 1.7 males to one female and 1.5 adults to one juvenile. Biases can arise from sampling methods when either using Distance data or Catch data. However due to the data sets obtained mean ratios were calculated from catch data. No significant result was determined across the years in the sex ratio (Regression,  $F= 0.02$ ,  $P = 0.90$ , d.f. =2) fig (4a) however it is clear that the ratio of males to females increases and decreases with abundance (comparison of fig(4a) to fig ()), as population increases the number of males in the population increases and vice versa. The same test however did find significance in age ratio across the years ( $F= 39.61$ ,  $P = 0.02$ , d.f. = 2) there does appear to be negative correlation between the numbers of adults to juveniles. Since the first data was collected in 1999 to the present day study in 2008 the numbers of adults to juveniles has steadily decreased consistently from year to year. , fig(4b).

**Fig.4.** (a)Graph showing sex ratio of males: females for *Cnemidophorus vanzoi* on Praslin Island 1999 to 2008 and (b) Continued on page 26; Graph showing Age ratio, adult: juvenile for *Cnemidophorus vanzoi* on Praslin Island 1999 to 2008





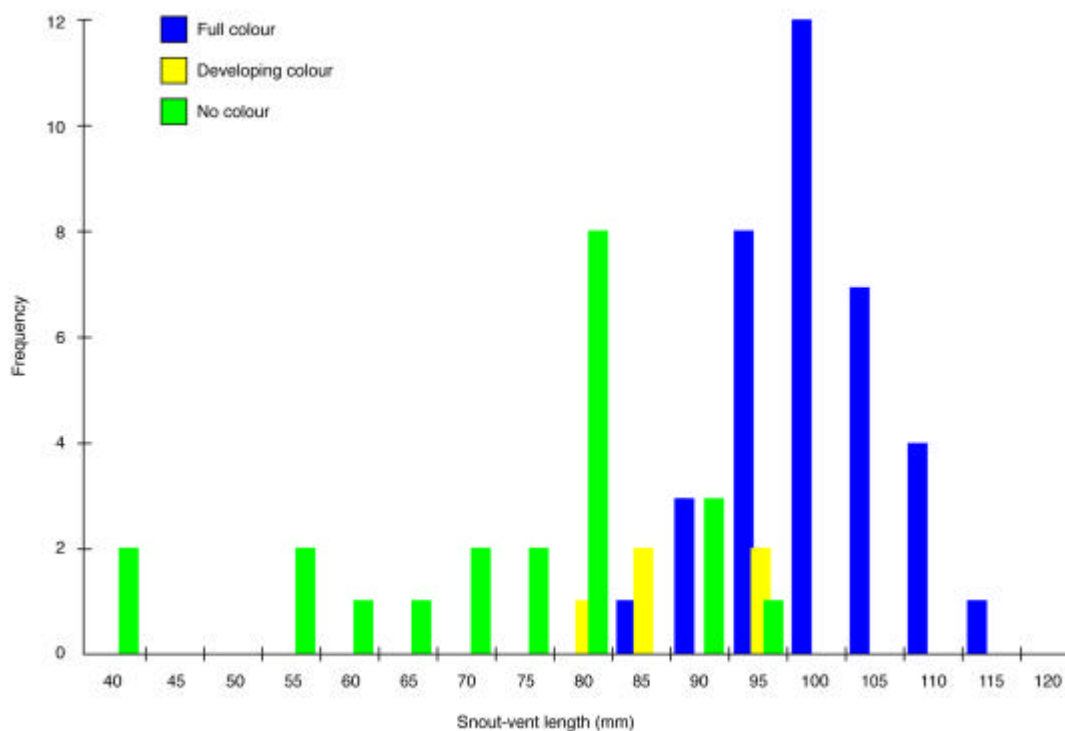
#### 4.4 Morphometrics

The smallest male to show adult colouration had an SVL of 84mm. All males with an SVL > 96mm showed adult colouring, Fig 5) and this replicates previous data collected by Dickinson & Fa (2000) who found that the smallest male to show adult colouration had an SVL of 81.1mm and all males above 98.5mm showed adult colouration. It can also be seen that by looking at fig 5) the number of males developing colour is not very high, the majority of lizards sampled were either fully coloured or juvenile. Data for juvenile males appears to show that there are roughly equal numbers of juveniles in each size class, although there a large proportion of juvenile males were found to have an SVL of around 80mm. It can also be seen that adult males exhibit the expected ‘normal’ distribution of SVL.

Mean SVL for adult male lizards in 2008 was  $101.8 \pm 7.5$  mm (range = 84 – 119,  $n = 41$ ). SVL for adult females was somewhat smaller at  $81.7 \pm 3.5$  mm (range = 77 – 87,  $n = 19$ ). The mean body mass for adult males in 2008 was  $34.2 \pm 9.1$ g (range = 17 – 53,  $n = 40$ ), with adult females being lighter at  $14.3 \pm 2.0$ g (range = 11 – 17,  $n = 16$ ). Mean SVL for juvenile males was  $75.5 \pm 15.0$  mm (range = 41 – 96,  $n = 22$ ). Mean

SVL for juvenile females was  $68.2 \pm 9.3$  mm (range = 44 – 76,  $n = 18$ ). Juvenile males had a mean body mass of  $17.0 \pm 8.2$ g (range = 2 – 29,  $n = 22$ ), juvenile females however were lighter again with a mean body mass of  $10.2 \pm 3.5$ g (range = 2 – 15,  $n = 18$ ).

**Fig.5.** Presence of adult male colouration in relation to SVL size for *Cnemidophorus vanzoi* on Praslin Island 2008.

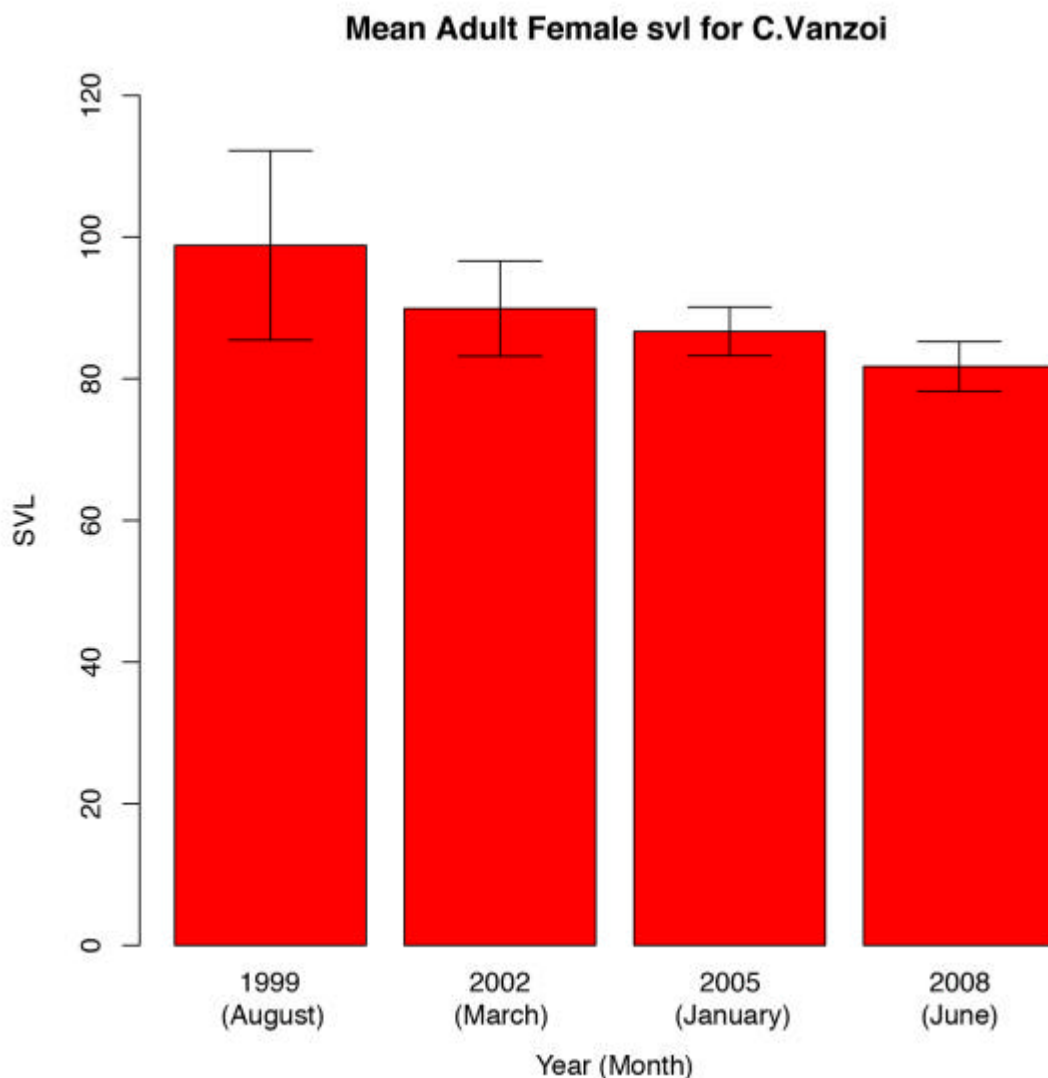


A two way ANOVA was carried out and showed a significant difference in SVL between age ( $F = 109$ ,  $P = <2.2e-16$ , d.f. = 92) as well as sex ( $F = 77$ ,  $P = 8.533e-14$ , d.f. = 92) and there was also significant interaction between the effects ( $F = 10.0$ ,  $P = 0.002$ , d.f. = 92). Adult males have a significantly larger SVL length than adult females, and adult females SVL is significantly larger than that of juvenile females and juvenile males. The same analysis was used to analyse body mass between age and sex and indicated significant results between age ( $F = 63$ ,  $P = 4.403e-12$ , d.f. = 92), although no significant difference was found between Adult female body mass and juvenile female body mass ( $t = -1.6$ ,  $\text{Pr}(>|t|) = 0.11$ ). Significance was also found between sex ( $F = 104$ ,  $P = <2.2e-16$ , d.f. = 92) and also significant interaction between the effects ( $F = 17$ ,  $P = 8.104e-05$ , d.f. = 92). Thus males weigh significantly more than adult females and adult females weighed significantly more than juvenile

males, but there was no significant difference between adult females and juvenile females.

SVL was also pooled across all years where an ANCOVA analysis was carried out resulting in a significant effect for age ( $F = 311$ ,  $P = <2.2e-16$ , d.f. = 221), sex ( $F = 135$ ,  $P = <2.2e-16$ , d.f. = 221), year ( $F = 11$ ,  $P = 0.0009$ , d.f. = 221) and the interaction between age and sex ( $F = 28$ ,  $P = 3.529e-07$ , d.f. = 221). However the significant result regarding year is limited only to adult females ( $t = -5.252$ ,  $\Pr(>|t|) = 0.000246$ ), fig 6.

**Fig.6.** Graph showing reduction in Adult Female *Cnemidophorus vanzoi* on Praslin Island 1999-2008.



Body mass was pooled across all years where the same ANCOVA analysis was carried out resulting in a significant effect for age ( $F = 217$ ,  $P = <2.2e-16$ , d.f. = 222),

sex ( $F= 193$ ,  $P= <2.2e-16$ , d.f. = 222), and the interaction between age and sex ( $F= 32$ ,  $P= 4.388e-08$ , d.f. 222). However there was no significant result for year ( $F=0.9$ ,  $P = 0.34$ , d.f. = 221).

#### **4.5 Morphometrics and Habitat Selection**

Body mass was tested against the four main habitats found on Praslin Island using ANOVA and was found to not be significantly correlated ( $F= 2.5$ ,  $P= 0.07$ , d.f. = 91) in 2008. Thus there is no significant difference in BM between the age or sex groups in any of the different main habitat types on Praslin Island.

Habitat selection was also tested between age and sexes using GLM analysis. Significant results were found for age, however only between main habitat types Manchaneel ( $Z=3.0$ ,  $\Pr (>|z|) = 0.003$ ), Mixed wood ( $Z= 2.016$ ,  $\Pr (>|z|) = 0.04$ ) and Shrub ( $Z= 0.006$ ,  $\Pr (>|z|) = 0.006$ ) no other habitat variables showed any significance in habitat selection between the age groups, indicating that adults utilize these habitats more than juveniles. The same test failed to identify any significant habitat selection between the two sexes, indicating that habitat is utilized in a similar way between both sex groups.

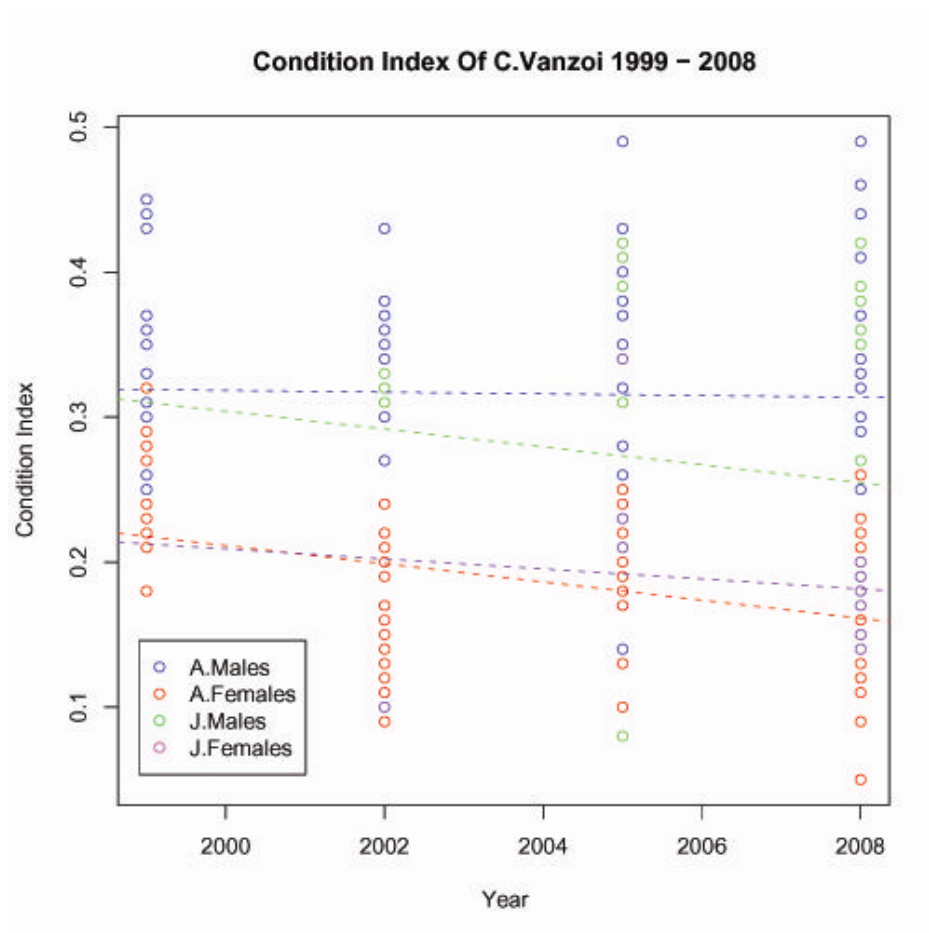
#### **4.6 General Habitat Selection**

Habitat selection was tested using general linear models to identify if habitat selection of caught lizards on Praslin island was random or not. The results indicated that some habitat selection was not random. Significance was identified to mixed woodland ( $Z = -2.128$ ,  $\Pr = (>|z|) = 0.03$ ) only for the main habitat types on Praslin. Microhabitat selection favoured areas with ground vegetation ( $Z = 2.95$ ,  $\Pr = (>|z|) = 0.003$ ), Rock ( $Z = 2.56$ ,  $\Pr = (>|z|) = 0.01$ ), Leaf ( $Z = 2.39$ ,  $\Pr = (>|z|) = 0.02$ ) and bare ground ( $Z = 2.62$ ,  $\Pr = (>|z|) = 0.009$ ). Other important variables included areas of high shrub cover ( $Z = 3.25$ ,  $\Pr = (>|z|) = 0.001$ ) and high canopy cover ( $Z = 3.60$ ,  $\Pr = (>|z|) = 0.0003$ ), as well as areas high in shade ( $Z = -2.42$ ,  $\Pr = (>|z|) = 0.02$ ) avoiding areas of full sun ( $Z = -0.67$ ,  $\Pr = (>|z|) = 0.50$ ).

## 4.7 Body Condition

The CI for all age and sex groups was pooled across all years and ANCOVA was used to test for significance. No significant difference was found in body condition for age or sex regarding year ( $F = 0.005$ ,  $P = 0.94$ , d.f. = 221), however significance was found for age ( $F = 162$ ,  $P = <2.2e-16$ , d.f. = 221) and sex ( $F = 157$ ,  $P = <2.2E-16$ , d.f. = 221). There was also a significant interaction found between effects ( $F = 16$ ,  $P = 8.928e-05$ , d.f. = 221) although this was limited to juvenile males only. Thus CI has stayed relatively stable since the first data was collected in 1999, fig.7.

**Fig.7.** Maximal model showing CI for *Cnemidophorus vanzoi* on Praslin Island 1999 – 2008, with CI stable.

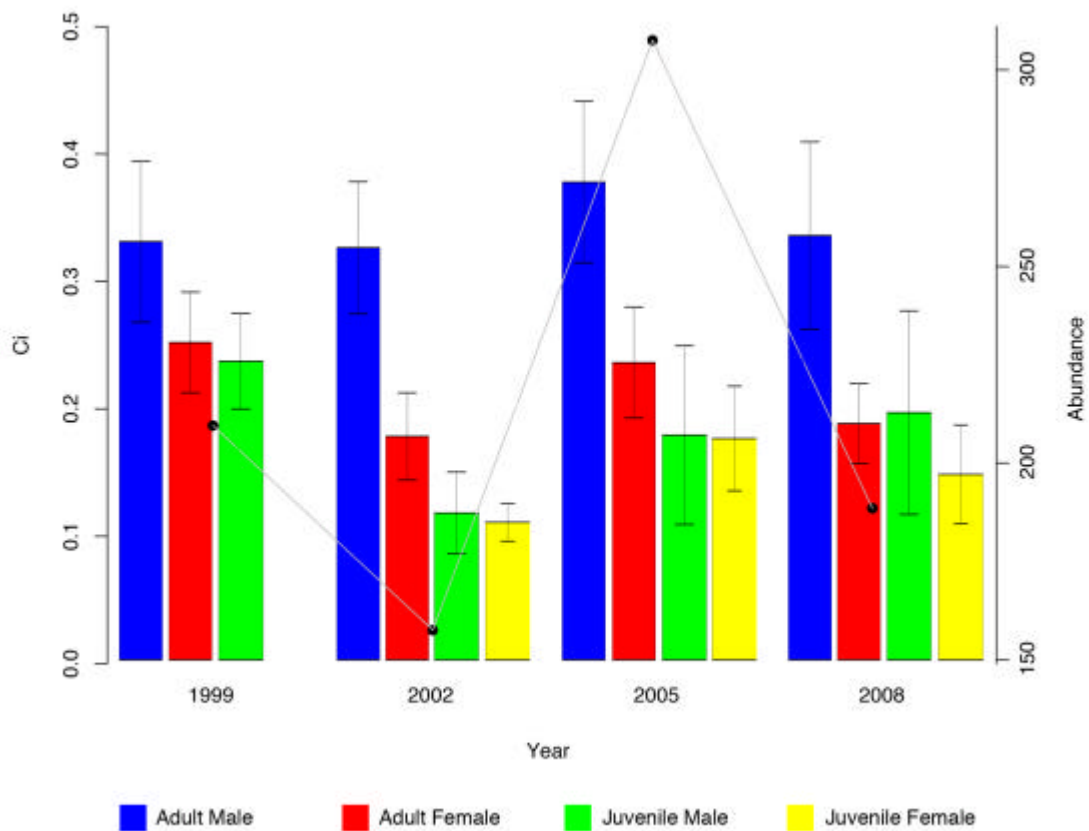


Although CI has remained stable across years, an ANOVA test was carried out to identify if there is a significant difference between body conditions from one year to another. ANOVA identified that Year was in fact significant ( $F = 6.8$ ,  $P = 0.0002$ , d.f.

= 219) and CI can in fact change significantly from year to year, fig.8, although usually not the case with Adult males, where CI stays relatively constant.

CI was also pooled together with abundance and illustrated on fig. 8, although relationship has not been tested for significance. CI loosely fits with abundance, thus in times of higher abundance it appears that CI also rises.

**Fig.8.** Mean CI for *Cnemidophorus vanzoi* on Praslin Island 1999 – 2008, pooled against abundance for *Cnemidophorus vanzoi* on Praslin Island during the same years.



## 5. Discussion

Providing good estimations of population sizes can prove challenging, with methods designed for reptiles suffering from many shortcomings (Heyer *et al*, 1994). Despite this fact, data collection during this study proved relatively easy, producing sound estimates for the lizard population on Praslin. Both sampling methods; DISTANCE (Laake *et al*, 1996) and PETERSEN (Krebs, 1989) gave very similar population estimates for 2008 (mean;  $n = 183$ ). Estimating population abundance using the mark recapture technique is often thought to underestimate population size, as the population is estimated from the catchable population only, however population estimates generated from PETERSEN provided an estimate higher ( $n = 186$ ) than that generated from distance ( $n = 181$ ), reflecting the larger sample size used in this study (Krebs, 1989). The difference between estimates was not significantly different, thus providing a reliable population estimate, with relatively low confidence intervals.

Mark recapture techniques are intrusive and stressful to the study population, however distance sampling is not, and in most cases would be the ideal method to use to estimate population abundance. Even though it is relatively time consuming, minimising the stress of the population is of great importance, even more so for species of a conservation concern. However, if as in this study, the population is already being sampled to monitor body condition, then mark recapture techniques would be the ideal method to estimate abundance, providing larger sample sizes are taken into consideration. Although in itself mark recapture is also time consuming, by combining efforts of abundance and condition, it is effective in reducing the amount of time required in the field, thus reducing the amount of money needed to be spent on monitoring - an important factor to take into consideration in a discipline such as this one that is lacking in funds.

Tropical lizards have evolved life history strategies to accommodate resource fluctuations associated with the wet and dry seasons, (James and Shine, 1988; Vitt and Blackburn, 1991, Wilson, 1991; Christian and Bedford, 1995). Praslin Island shows a pronounced dry season during the months of January to May, with low precipitation and vegetation, increased temperatures and low abundance of invertebrate prey (Dickinson and Fa. 2000). Correspondingly population trends and

general condition in the translocated lizards follows this pattern and exhibits a drop in abundance and condition during the dryer months. This has been observed also in the West Indian Anoles, where a drop in body mass was correlated with a significant reduction of invertebrates during the dry season (Giffiths and Christian, 1996). Population abundance was at its highest in 2005 (n= 305) which was sampled at the beginning of January, the end of the wet season, where vegetation and invertebrate prey should be at its highest and relates to the strong seasonal changes in fat reserves and seasonal cycling of lipids, with the highest fat reserves recorded directly after the wet season (Vitt, 1983). In comparison population abundance was at its lowest when sampled in 2002 during March, midway through the dry season (n = 155). Population abundance would be expected to be at an all time low at the very end of the dry season due to lower food supplies resulting in reduced growth and activity (Giffiths and Christian, 1996; Smith, 1996). However when the population was sampled during this study in June the abundance was higher than that of 2002 (n = 186), this can be accounted for however by the hatching of juvenile lizards, which is timed with the start of the wet season to ensure plentiful food supply for the young (pers comm), As well as seasonal fluctuations, the lizards are also subject to yearly fluctuation effects i.e. weather differences from year to year, and this too can have effects on abundance. Most of the variance carried out in this study, however, can be contributed to seasonal sampling differences. Overall, however the translocated population has remained stable since 1999.

CI in males stayed relatively stable throughout the different sampling seasons although it was at its highest during the January sampling in 2005 and changes in male CI are generally related to energetically expensive activities i.e. breeding. Although it has been discussed that the *Cnemidophorus* species have reproductive seasons of various durations and frequencies (Vitt and Breitenbach, 1993), they generally occur during the wet season (Andrews, 1989). During this study copulation was witnessed on a number of occasion as well as many pre mating rituals, suggesting that the breeding season of this species is towards the end of the dry season, allowing hatching to coincide with the wet season and plentiful food. Thus this can give one explanation why male CI was higher during the 2005 sampling, as energy was not being expended on breeding. Adult female, juvenile female and juvenile male CI however displayed more variation throughout the sampling seasons (Griffiths and

Christian, 1996). The change in adult female CI can be attributed not only to intra-specific competition between adult males for resources but also due to the energy expelled in reproduction.

CI has remained stable, however, since 1999 across all sex and age groups as a whole, although it should be noted that although at this point in time it is not significant, male juveniles are experiencing a downward trend and this is something that should be monitored in future years. This trend is possibly due to the fact that male juveniles expend more energy reaching maturity (LeGalliard *et al*, 2005), than female juveniles and thus any fluctuation in resources will have a greater impact upon these individuals. Mean adult female CI was significantly lower than that of males and this is due to energy expenditure that goes into reproducing for a female i.e. the cost of egg production.

Sex ratio of the translocated population of lizards on Praslin Island has not significantly changed from year to year since 1999 (mean male to female: 1.8:1.0). However this figure is likely to be male biased due to the fact that males are easier to catch than females (Dickinson and Fa, 2000), thus the expected sex ratio for the lizards on Praslin is between one and two males for every one female, which is not much different to the normal 1:1 ratio found in most *Cnemidophorus* species (Cole and Dessauer, 1995).

Age ratio has experienced a significant drop in the number of adults: juveniles for the translocated population. During 1999 the ratio was 5.8:1.0 however numbers have been decreasing from year to year with a final figure of 1.5:1.0 estimated during this study in 2008. This suggests that towards the beginning of the translocation, there were some factors affecting the juvenile mortality i.e. predation or competition or even a reduction in adult fecundity. However this threat appears to have decreased as adult: juvenile ratio is now decreasing in favour of the juvenile, suggesting that today the juvenile mortality is comparatively low and adult fecundity is of a normal level.

Sexual size dimorphism is the result of intra-sexual competition as described by Dickinson and Fa (2000) and results from this study agree with and confirm their conclusions. This study found 6% of males above the minimum SVL associated with

adult colouration maintained juvenile colour. These types of males are known as 'sneaky males' where retaining juvenile colour limits the reproduction related intra-sexual aggression but allows them to reproduce, a phenomenon reported by Dearing and Shall (1994) in *C.arubensis* and *C.murinus* also. This is not the first time this has been reported in this species either, Dickinson and Fa (2000) encountered 16% of the male population retaining juvenile colour, and thus it appears that *C. vanzoi* follows *C.arubensis* and *C.murinus* in this behaviour too. SVL length identified a significant reduction in female adult SVL since 1999. There could be many reasons for this although Sears and Angilletta (2004) suggest that in times of reduced survival amongst juveniles; individuals will often mature faster in response to ensure reproduction before death. There is evidence that the juvenile population on Praslin was experiencing some kind of mortality a few years back and it could be quite possible that in response to that females juveniles (smaller and more likely to loose out to the other three groups) have responded by maturing faster, reducing overall body size in adult females to date. This effect should be monitored, theory suggests that as mortality decreases, size should stable out. The other age and sex groups however did not have any significant change in SVL since 1999. Body also showed no significant difference between the age and sex groups since 1999 and appears to be stable.

There was specific correlation between body mass and habitat on the Praslin lizards, indicating that either all habitats are as productive as each other or more likely the lizards move freely, foraging between the habitat types.

The study showed that the adult lizards were distributed on Praslin Island in a non random manner, with the lizards utilising more of the shrub and forested habitats, avoiding the grasslands (observed also in *C.arubensis*, Schall, 1974). However young juveniles are often seen more in open grass, as adults push them out of the prime habitats. Habitats preferred were shrub, mixed wood and manchineel, which is also reflected by positive correlations between, leaf litter and shrub cover.

Habitat utilization in lizards is a trade off between, thermoregulation (Vitt and Colli, 1999), food availability (Griffith and Christian, 1996), predator avoidance (stamps, 1983) and population density (Schall, 1974). However (Sartorius, 1999) suggested

that for *C. vanzoi*, thermoregulation is more than likely a primary cause for habitat selection, as discussed by Dickinson *et al*, (2001). The lack of cover in grass can make thermoregulation difficult for adults, and although mixed woodland is utilized significantly, the increase in exposure during the dry season may also disrupt thermoregulation and hence explain why canopy cover is of major significance, along with shaded habitats. Another reason why these habitats may be preferred is due to the prevalence of increased leaf litter, which is associated with high invertebrate density (Martin and Lopez (1998).

Overall the success of the project can be down to a clear concise objective, with simple but effective aims to follow. The project was facilitated with strong sound research techniques that have been tried and tested on numerous occasions, with in depth literature to provide background information. The project had a head start with already good management implementations in place and thus carrying out my research was rather simple and faced very little challenges. The main weaknesses of the project were mainly down to time constraints and lack of field personnel. With more time more in depth analysis could have been carried i.e. carrying out seasonal data and comparing these results with Dickinson and Fa (2000). Also more in depth habitat analysis could have been carried out taking into account more variables such as soil structure, elevation and food availability. One major contribution that my study lacked was a comparison of lizard's now to that of the source population. This would have also helped identify any changes that may be going on in the original population as well. A small problem faced on occasions during the sampling was from people living on the main land. Parties were held on a number of occasions with numerous people arriving on the island.

This leads on to future recommendations for management. The lizards on Praslin appear to be striving apart from the factors mentioned previously that need to be monitored, nothing really needs to change. However it would be an excellent opportunity to gather seasonal data on the lizards (carried out twice yearly for perhaps 3 - 5 years), to see how the fluctuations in resource really effects them and this would provide another dimension to the research already carried out on this species. It would also be really interesting to carry on where this study left off looking to see if there is a significant interaction between abundance and CI, which unfortunately due to time

constraints could not be carried out during this study. I recommend also that habitat utilisation should be carried out on the source population and then compared with data obtained from this and previous studies on the translocated population. This will help to identify original habitat selection of this species and if the translocated population are just making do with what they have. Finally I would recommend that there be more publicity about the lizard especially around Praslin and Dennery village, to ensure that the local people are aware of the lizard on Praslin Island and any damage that could be done if parties got out of hand i.e fires.

The translocation of this species has provided an exciting insight into a relatively unknown species. Data collected during this study combined with previous studies (Dickinson and Fa 2000; Dickinson *et al*, 2001 and Young *et al* 2006) has provided important baseline data essential for any future translocations of this species. It has also provided the essential long term monitoring recommended (Dodd and Seigel, 1991; Fischer *et al*, 2000) for successful translocations. The Praslin Island population has increased and remained stable since the original translocation back in 1995; sex ratios have remained constant and age ratios appear to be decreasing from an adult dominated population. There are a few issues that need to be monitored such as SVL size in adult females, but as such the evidence points to a thriving population. This translocation has led to a self sustaining population of viable numbers, with relatively few problems. All the data at this point in time suggests that this particular translocation has been a success, due to the small size of Praslin and the effects of demographic, environmental, genetic and catastrophic stochasticity (Shaffer, 1987). The population should continually be monitored at regular intervals. Despite the existence of extensive and costly work, good management, leadership and decision making have been a key component in the apparent success of this particular translocation.

## **6. ACKNOWLEDGEMENTS**

I would like to thank my supervisors Dr John Fa and Dr Richard Young of Durrell Wildlife Preservation Trust, for providing much appreciated guidance and continual support in the realisation of this project. As well as Dr Stephan Funk of Durrell Wildlife Preservation Trust, who helped advice me on numerous occasions.

I am also very grateful to Matthew Morton of Durrell Wildlife Preservation Trust, whose help and guidance in the field was unprecedented. A big thank you to the St. Lucia Forestry Department for giving me their permission to work on the Island and continued support during the field study. Thank you to Mr John Lydon for allowing me to use his data, which was collected on the lizard population back in 1999.

Thank you to Mr Stephen Lesmond, for your never ending support in the field and in depth expertise of the St. Lucian Whiptail and Mr Tim Jnr. Baptiste for continued support and expertise in the field.

I would like to thank Miss Erin Murton and the Durrell Wildlife Preservation Trust Volunteers of St. Lucia 2008 for their continued support and assistance throughout the field study.

Finally I would like to say a big thank you to friends and family who have continued to support me throughout the project, big thanks to you all.

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## APPENDIX A: Distance output

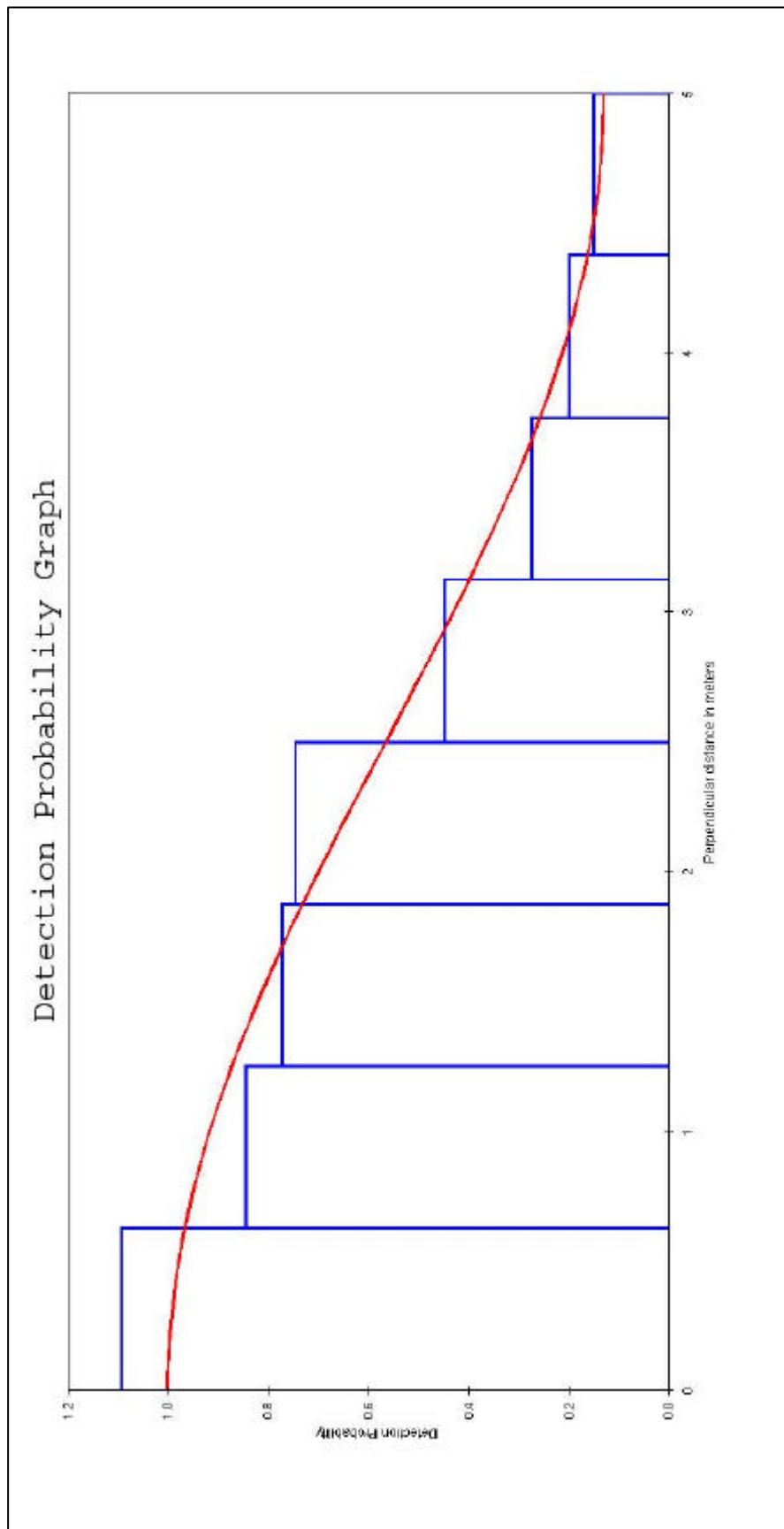
Figure A1. The seven different models run in Distance 5.0.

ID	1	2	3	4	Name	Created	# params	Delta AIC	AIC	ESW/EDR	D	D LCL	D UCL	D CV
1	1	1	1	1	Default	14/08/2008 12:19:01	2	0.00	633.93	2.77	176.202	116.660	266.132	0.187
4	1	2	3	3	UniC 5%	14/08/2008 12:25:55	1	0.00	526.61	2.83	164.883	109.865	247.453	0.181
3	1	2	2	2	HNHP 5%	14/08/2008 12:23:56	1	0.84	527.45	2.79	166.745	110.617	251.353	0.186
2	1	2	1	1	HNC 5%	14/08/2008 12:22:24	1	0.84	527.45	2.79	166.745	110.617	251.353	0.186
5	1	2	4	4	UniSP 5%	14/08/2008 12:32:13	2	1.50	528.11	2.84	164.323	109.081	247.541	0.185
6	1	2	5	5	HazC 5%	14/08/2008 12:41:59	3	3.80	530.41	2.67	174.053	112.819	268.524	0.205
7	1	2	6	6	HazSP 5%	14/08/2008 12:43:42	2	3.99	530.60	2.88	162.082	106.300	247.137	0.196

Figure A2. Output for model: Uniform Cosine 5% used in this study.

Density Estimates/Global					
Effort	:	2075.000			
# samples	:	9			
Width	:	5.000000			
# observations:		182			
Model 2					
Uniform key, $k(y) = 1/W$					
Cosine adjustments of order(s) : 1					
Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
f(0)	0.35398	0.14675E-01	4.15	0.32619	0.38414
p	0.56501	0.23423E-01	4.15	0.52065	0.61315
ESW	2.8250	0.11712	4.15	2.6032	3.0657
n/L	0.87711E-01	0.15408E-01	17.57	0.58676E-01	0.13111
DS	155.24	28.019	18.05	103.48	232.89
E(S)	1.0621	0.13235E-01	1.25	1.0363	1.0886
D	164.88	29.831	18.09	109.87	247.45
N	144.00	26.053	18.09	96.000	216.00
-----					
Measurement Units					
-----					
Density: Numbers/hectares					
ESW: meters					
Component Percentages of Var(D)					
-----					
Detection probability	:	5.3			
Encounter rate	:	94.3			
Cluster size	:	0.5			

**FIGURE A3.** Graph showing detection probability for Distance data on Praslin 2008.

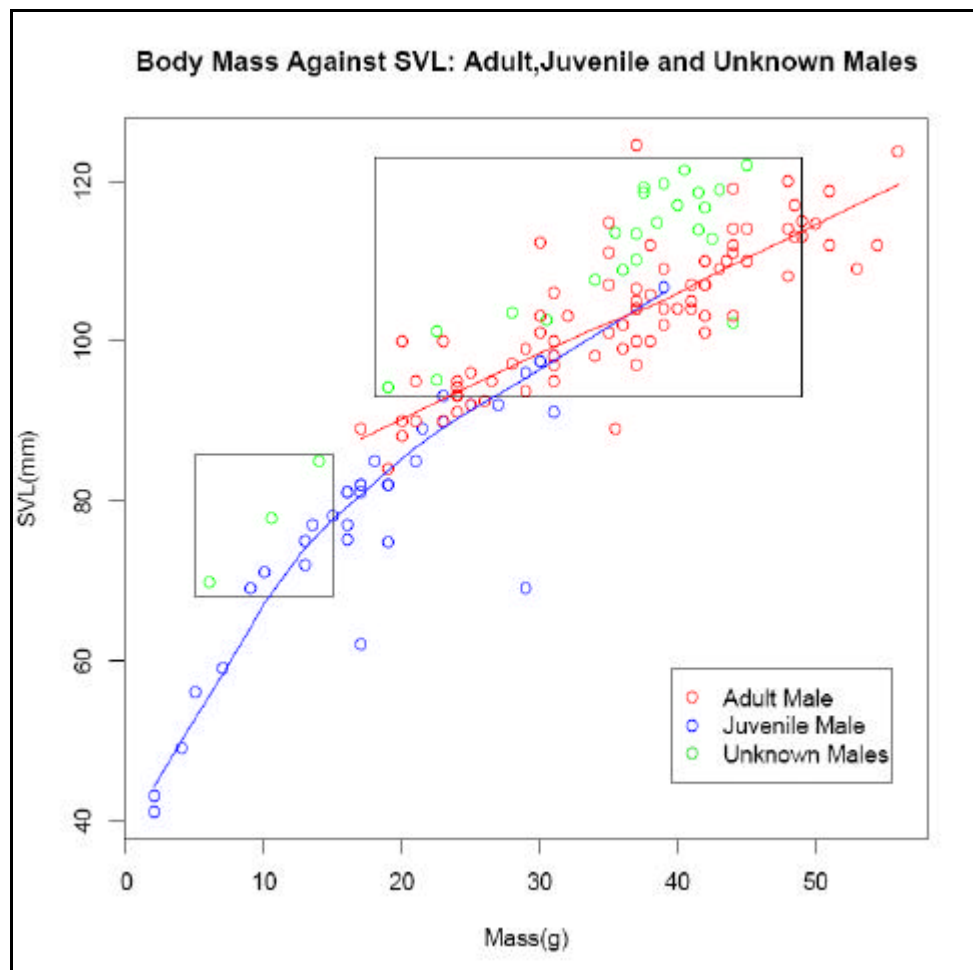


**APPENDIX B: Identification of Unknown male *Cnemidophorus vanzoi* from 2002 data.**

Data for this study include data generated from research projects in 1999, 2002 and 2005. Data from 2002 was missing the age status of each individual caught i.e. adult juvenile. Females were worked out easily from SVL length provided, however as no indication was given as to the status of male (no descriptive text on colouration or photographs), it was decided that rather than omit this data, to try and identify Adult males from juvenile males using all data.

The Method: Data for SVL against BM for all male *C. vanzoi* was plotted on a scatter graph identifying the known adults males and juveniles males from 1999,2005 and 2008 with specific colours and a best fit line was calculated for each age group. The unknown males of 2002 were then placed into the scatter graph and a rough estimation could be made as to the age.

**FIGURE B1.**



**Result:** Three males fall within juvenile size range, with the rest falling in adult size range. This is not an accurate test to identify age status but with no method described other than colouration to identify adult status in males, it was decided that rather than omit and loose data for 2002 a rough estimate could be attained using this method

## APPENDIX C: Statistical Outputs from R.

The Following is the statistical outputs gained from R, where necessary only minimum maximal models have been shown.

- **Population trend data 1999 – 2008.**

```
Call:
lm(formula = number ~ year)

Residuals:
    1     2     3     4 
 6.8 -53.9  87.4 -40.3 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -5596.90    23340.12  -0.240   0.833
year          2.90       11.65   0.249   0.827

Residual standard error: 78.15 on 2 degrees of freedom
Multiple R-squared:  0.03005,    Adjusted R-squared: -0.4549 
F-statistic: 0.06197 on 1 and 2 DF,  p-value: 0.8266
```

- **Sex ratio trend 1999 – 2008.**

```
Call:
lm(formula = Sex.ratio ~ year)

Residuals:
    1     2     3     4 
-0.0940  0.1955 -0.1090  0.0075 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   8.8220     51.2945   0.172   0.879
year          -0.0035     0.0256  -0.137   0.904

Residual standard error: 0.1717 on 2 degrees of freedom
Multiple R-squared:  0.009258,    Adjusted R-squared: -0.4861 
F-statistic: 0.01869 on 1 and 2 DF,  p-value: 0.9038
```

- **Age ratio trend data 1999 - 2008**

```
Call:
lm(formula = Age.ratio ~ year)

Residuals:
    1     2     3     4 
0.3364 -0.6387  0.2682  0.0341 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 1027.98787  162.79228   6.315  0.0242 *
year        -0.51137   0.08125  -6.293  0.0243 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5451 on 2 degrees of freedom
Multiple R-squared:  0.9519,    Adjusted R-squared: 0.9279 
F-statistic: 39.61 on 1 and 2 DF,  p-value: 0.02433
```

- **SVL data 2008**

```
Call:
lm(formula = model)

Residuals:
    Min       1Q   Median       3Q      Max
-34.545  -3.530   1.875   5.460  20.455

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    81.125     2.408  33.689 < 2e-16 ***
sex M           20.400     2.849   7.160 1.93e-10 ***
age J          -12.958     3.310  -3.915 0.000173 ***
sex M :age J   -13.021     4.182  -3.114 0.002464 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 9.632 on 92 degrees of freedom
Multiple R-squared:  0.6801,    Adjusted R-squared:  0.6697
F-statistic: 65.21 on 3 and 92 DF,  p-value: < 2.2e-16
```

- **SVL trend data 1999 – 2008**

```
Call:
lm(formula = mos4)

Residuals:
    Min       1Q   Median       3Q      Max
-34.732  -5.184   1.108   5.881  20.268

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1563.4876    396.5862   3.942 0.000108 ***
ageJ        -12.3543     2.2037  -5.606 6.14e-08 ***
sexM         20.3656     1.6117  12.636 < 2e-16 ***
year         -0.7375     0.1979  -3.727 0.000246 ***
ageJ:sexM   -14.8202     2.8217  -5.252 3.53e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 9.492 on 221 degrees of freedom
Multiple R-squared:  0.6869,    Adjusted R-squared:  0.6813
F-statistic: 121.2 on 4 and 221 DF,  p-value: < 2.2e-16
```

- **BM data 2008**

```
Call:
lm(formula = model2)

Residuals:
    Min       1Q   Median       3Q      Max
-17.150  -3.222   0.750   3.778  18.850

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    14.250     1.831   7.781 1.03e-11 ***
sex1 M          19.900     2.167   9.183 1.19e-14 ***
age1 J          -4.028     2.517  -1.600   0.113
sex1 M :age1 J -13.122     3.181  -4.126 8.10e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.326 on 92 degrees of freedom
Multiple R-squared:  0.6672,    Adjusted R-squared:  0.6563
F-statistic: 61.47 on 3 and 92 DF,  p-value: < 2.2e-16
```

- **BM trend data 1999 – 2008**

```
Call:
lm(formula = bm ~ age + sex + age:sex)

Residuals:
    Min       1Q   Median       3Q      Max
-19.2123  -4.6058   0.2985   4.7665  19.7877

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  17.606      1.040  16.926 < 2e-16 ***
ageJ         -6.799      1.702  -3.995 8.81e-05 ***
sexM         18.606      1.270  14.652 < 2e-16 ***
ageJ:sexM    -12.616      2.224  -5.671 4.39e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.501 on 222 degrees of freedom
Multiple R-squared:  0.6658,    Adjusted R-squared:  0.6613
F-statistic: 147.4 on 3 and 222 DF,  p-value: < 2.2e-16
```

- **BM and Habitat 2008**

```
Call:
lm(formula = mod5)

Residuals:
    Min       1Q   Median       3Q      Max
-1.715e+01 -3.204e+00  1.075e-15  3.832e+00  1.885e+01

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  15.000      1.723   8.708 1.02e-13 ***
age J       -4.778      2.436  -1.961 0.052800 .
sex M       19.150      2.074   9.233 7.87e-15 ***
age J :sex M -12.372      3.114  -3.973 0.000139 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.308 on 94 degrees of freedom
(48 observations deleted due to missingness)
Multiple R-squared:  0.6617,    Adjusted R-squared:  0.6509
F-statistic: 61.29 on 3 and 94 DF,  p-value: < 2.2e-16
```

- **Habitat selection 2008 age: habitat**

```
Call:
glm(formula = y ~ habitat, family = binomial)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.007  -1.313   0.535   1.047   1.626

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.0116      0.5839  -1.733  0.08317 .
habitatM     2.8834      0.9580   3.010  0.00262 **
habitatMW     1.3253      0.6573   2.016  0.04377 *
habitatS     2.0531      0.7526   2.728  0.00637 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)
```

Null deviance: 130.88 on 97 degrees of freedom  
Residual deviance: 116.87 on 94 degrees of freedom  
AIC: 124.87

Number of Fisher Scoring iterations: 4

- **Habitat selection 2008 Sex: habitat**

Call:  
glm(formula = y ~ bg, family = binomial)

Deviance Residuals:  
Min 1Q Median 3Q Max  
-1.2640 -0.9785 -0.8218 1.2802 1.5810

Coefficients:  
Estimate Std. Error z value Pr(>|z|)  
(Intercept) -0.9120 0.3390 -2.690 0.00714 \*\*  
bg 0.9490 0.5945 1.596 0.11043  
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 129.92 on 97 degrees of freedom  
Residual deviance: 127.32 on 96 degrees of freedom  
AIC: 131.32

Number of Fisher Scoring iterations: 4

- **Habitat selection – testing for random selection**

Call:  
glm(formula = y ~ hab + gv + r + l + bg + srub + cc + sun, family =  
binomial)

Deviance Residuals:  
Min 1Q Median 3Q Max  
-2.368e+00 2.007e-05 1.233e-01 4.501e-01 2.078e+00

Coefficients:  
Estimate Std. Error z value Pr(>|z|)  
(Intercept) -13.6219 4.5972 -2.963 0.003046 \*\*  
habM 17.2838 1361.8940 0.013 0.989874  
habMW -3.4187 1.6065 -2.128 0.033340 \*  
habS -0.4344 1.4773 -0.294 0.768710  
gv 8.9474 3.0385 2.945 0.003233 \*\*  
r 6.2488 2.4488 2.552 0.010716 \*  
l 6.0496 2.5294 2.392 0.016769 \*  
bg 5.8572 2.2383 2.617 0.008876 \*\*  
srub 4.9076 1.5106 3.249 0.001159 \*\*  
cc 6.2708 1.7404 3.603 0.000314 \*\*\*  
sunF -0.6790 1.0117 -0.671 0.502128  
sunS -2.1442 0.8880 -2.415 0.015752 \*  
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 139.394 on 127 degrees of freedom  
Residual deviance: 71.033 on 116 degrees of freedom  
AIC: 95.033

Number of Fisher Scoring iterations: 17

- **Body Condition trend data 1999 – 2008**

Call:

```
lm(formula = ConditionIndex ~ Age + sex + Year + Age:sex)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.155792	-0.038724	0.003595	0.041122	0.214208

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	1.1234710	2.6399157	0.426	0.670835
AgeJ	-0.0581094	0.0146692	-3.961	0.000101 ***
sexM	0.1347918	0.0107284	12.564	< 2e-16 ***
Year	-0.0004579	0.0013174	-0.348	0.728506
AgeJ:sexM	-0.0749768	0.0187832	-3.992	8.93e-05 ***

---

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.06319 on 221 degrees of freedom

Multiple R-squared: 0.6031, Adjusted R-squared: 0.5959

F-statistic: 83.96 on 4 and 221 DF, p-value: < 2.2e-16