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POPULATION STRUCTURE AND REPRODUCTIVE MIGRATION OF LAND CRABS ON GRAND CAYMAN ISLAND

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Kinsey N. Tedford

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By D. Bass

Name **Committee Chairperson**

Name **Committee Member**

Chad B King

Name **Committee Member**

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TABLE OF CONTENTS

Acknowledgments……………………………………………………………………..iii

List of Figures………..…………………………………………….………....………ix

List of Tables………...…………………………………………….……........….…xii

List of Appendices………..……………………………………….…….........…xiii

Thesis Abstract………..………………………………………….………....……xiv

I. CHAPTER 1: THESIS INTRODUCTION……………………………….……….…1

Literature Cited…………………………………………………………......10

II. CHAPTER 2: SIZE COMPOSITION AND POPULATION CHARACTERISTICS OF THE WHITE LAND CRAB, *CARDISOMA GUANHUMI*, ON GRAND CAYMAN ISLAND

Abstract……………………………………………………...………...16

Introduction…..…………………………………………………………..17

Methods…..…………..……………………………………………...…...18

Results…..……………………………………………………………….21

Discussion…..……………..……………………………………………......23

Acknowledgments…..…...……………………………………………......28

Literature Cited…..……………..………………………………...………...29

Figure 1…..……………..…………………………...………………...35

Figure 2…..……………..………………………………………………..36

Figure 3…..……………..………………………………………………..37

Figure 4…..……………..………………………………………………..38

Figure 5…..……………..………………………………………………..39

Table 1……..…………………..…………………………………………………….40

III. CHAPTER 3: POPULATION STRUCTURE AND HABITAT DESCRIPTION OF THE BLACK LAND CRAB (*GECARCINUS RURICOLA*) ON GRAND CAYMAN ISLAND

Abstract……………………………………………………………………………..41
Introduction…………..……………………………………………………………..42
Methods…..…………..……………………………………………………………..43
Results…..…………………………………………………………………………..45
Discussion…..……………..………………………………………………………..47
Acknowledgments…..…...…………………………………………………………..50
Literature Cited…..……………..…………………………………………………..52
Figure 1…..……………..…………………………………………………………..55
Figure 2…..……………..…………………………………………………………..56
Figure 3…..……………..…………………………………………………………..57
Figure 4…..……………..…………………………………………………………..58
Figure 5…..……………..…………………………………………………………..59
Figure 6…..……………..…………………………………………………………..60
Figure 7…..……………..…………………………………………………………..61
Figure 8…..……………..…………………………………………………………..62
Figure 9…..……………..…………………………………………………………..63
Figure 10…..………………………………………………………………………..64
Figure 11…..………………………………………………………………………..65
Figure 12…..………………………………………………………………………..66

Table 1……67

Table 2……68

Table 3……69

IV. CHAPTER 4: COASTAL MIGRATION OF THE BLACK LAND CRAB (*GECARCINUS RURICOLA*) ON GRAND CAYMAN ISLAND

Abstract……70

Introduction……71

Methods……74

Results……78

Discussion……81

Acknowledgments……88

Literature Cited……89

Figure 1……55

Figure 2……56

Figure 3……94

Figure 4……95

Figure 5……96

Figure 6……97

Figure 7……98

Figure 8……99

Figure 9……100

Figure 10……101

Figure 11……102

Figure 12…..………………………………………………………………103

Figure 13…..………………………………………………………………104

Table 1…....………………..…………………………………………...105

V. CHAPTER 5: GENERAL SUMMARY…..……………..………………………….106

Literature Cited…..……………..……………………………………………114

Appendices

Appendix A1…..……………..…………………………………………………120

Appendix A2…..……………..…………………………………………………127

Appendix A3…..……………..…………………………………………………134

Appendix A4…..……………..…………………………………………………155

Appendix A5…..……………..…………………………………………………156

Appendix A6…..……………..…………………………………………………157

LIST OF FIGURES

CHAPTER 2

1. Map displaying the study area within Barkers National Park, West Bay, Grand Cayman…………………………………………………………………...35
2. Map displaying the study area within Barkers National Park, Grand Cayman in regards to land use/land cover classifications…………………………………36
3. *Cardisoma guanhumi* color patterns documented at Barkers National Park, Grand Cayman from mid-May to early August in 2016.…………………...……37
4. Sex ratio of *C. guanhumi* males and females by carapace width (mm) size class, sampled at Barkers National Park, Grand Cayman, from mid-May to early August in 2016……………………………………………………...…...38
5. Carapace width (mm) ranges for *C. guanhumi* males, non-ovigerous females, and ovigerous females in relation to the four color patterns, sampled at Barkers National Park, Grand Cayman from mid-May to early August in 2016…………………………………………………………………………39

CHAPTER 3

1. Map displaying the study area on/along Queen’s Highway, East End, Grand Cayman………...………………………………………………………………...55
2. Map displaying the study area on/along Queen’s Highway, Grand Cayman illustrating land use/land cover classifications…………….……...………………..56
3. Carapace width (mm) versus major chela length (mm) for *G. ruricola* males captured from May to August in 2016 along Queen’s Highway……….……….57
4. Carapace width (mm) versus major chela length (mm) for *G. ruricola* non-ovigerous females and ovigerous females captured from May to August in 2016 along Queen’s Highway…………………………………………………58
5. Carapace width (mm) versus mass (g) for *G. ruricola* males captured from May to August in 2016 along Queen’s Highway………………………………...59
6. Carapace width (mm) versus mass (g) for *G. ruricola* non-ovigerous females and ovigerous females captured from May to August in 2016 along Queen’s Highway……………………………………………………………………….60
7. Carapace width (mm) versus interorbital distance (mm) for *G. ruricola* males captured from May to August in 2016 along Queen’s Highway………………...61

8. Carapace width (mm) versus interorbital distance (mm) for *G. ruricola* non-ovigerous females and ovigerous females captured from May to August in 2016 along Queen's Highway……………………………………………………62

9. Carapace width (mm) versus fronto-orbital distance (mm) for *G. ruricola* males captured from May to August in 2016 along Queen's Highway…………63

10. Carapace width (mm) versus fronto-orbital distance (mm) for *G. ruricola* non-ovigerous females and ovigerous females captured from May to August in 2016 along Queen's Highway……………………………………………………64

11. Carapace width (mm) ranges for *G. ruricola* males, non-ovigerous females, ovigerous females from May to August in 2016 and 2017 along Queen's Highway, East End, Grand Cayman……………………………………...…..65

12. Photos from the study area on/along Queen's Highway, East End, Grand Cayman……………………………………………………………………….66

CHAPTER 4

1. Map displaying the study area on/along Queen's Highway, East End, Grand Cayman…………………………………………………………………...55

2. Map displaying the study area on/along Queen's Highway, Grand Cayman illustrating land use/land cover classifications…………………..……………...56

3. Number of active *G. ruricola* individuals within 500m^2 sections on the coastal versus inland roadsides along Queen's Highway, Grand Cayman during the summer from May 22 to August 5, 2017…………….…………….94

4. Spatial distribution of *G. ruricola* migrations during the reproductive season from May 22 to August 5, 2017……………………………………………….95

5. Results of *k*-means clustering indicating there were two clusters of *G. ruricola* individuals along Queen's Highway in 2017……………………………………96

6. Temporal migration displaying the number of active *G. ruricola* individuals on Queen's Highway, Grand Cayman throughout the collection dates (May 22 to August 5, 2017)……………………………...97

7. Number of active *G. ruricola* on the road versus roadkills encountered during the road surveys within each road section (850m^2) along Queen's Highway, Grand Cayman from May 22 to August 5, 2017………………………………...98

8. Moon illumination (%) values obtained from the U.S. Naval Observatory and the number of *G. ruricola* individuals encountered on Queen's Highway throughout the 2017 data collection on Grand Cayman……………………………99

9. Number of male *G. ruricola* individuals in each lunar phase category for summer 2017…………………………………………………………………100

10. Number of non-ovigerous *G. ruricola* individuals in each lunar phase category for summer 2017………………………………………………………………..101

11. Number of ovigerous *G. ruricola* individuals in each lunar phase category for summer 2017…………………………………………………………………102

12. Rainfall amounts (mm) obtained from the Cayman Water Authority and number of active *G. ruricola* recorded on the road during summer 2017 along Queen's Highway, East End, Grand Cayman……………………………………..103

13. Drone images of the various road sections within the study area on/along Queen's Highway, East End, Grand Cayman……………………………………..104

LIST OF TABLES

CHAPTER 2

1. Morphometrics and handedness ratios for data collected on *C. guanhumi* from mid-May to early August in 2016 at Barkers National Park, Grand Cayman……………………………………..……………………………………40

CHAPTER 3

1. Morphometrics obtained for *G. ruricola* from May to August in 2016 along Queen’s Highway, East End, Grand Cayman……………………………………67

2. Descriptive statistics of *G. ruricola* carapace width (mm) by size and sex measured on/along Queen’s Highway from May to August in 2016 and 2017……………………………………………………………………………68

3. Dominant flora within the coastal and inland roadsides (500m^2) from May to August in 2017 along Queen’s Highway, East End, Grand Cayman……………69

CHAPTER 4

1. Summary of the two clusters observed in each sex based on *k*-cluster analyses……………………………………………………..…………….105

LIST OF APPENDICES

A1. Raw data for *C. guanhumi* (Chapter 2)…………….………..…………………120

A2. Raw data for *G. ruricola* (Chapter 3)…………...…….…………..………127

A3. Raw data for *G. ruricola* (Chapter 3, Chapter 4)……………….…………...134

A4. Dominant flora identified at Barkers National Park, West Bay, Grand Cayman in July, 2017…….……………………...……….……………..155

A5. Starting location for each marked 100m road section along Queen's Highway, East End, Grand Cayman (Chapter 4)………………………………156

A6. Specific locations within the road sections (850m^2) on Queen's Highway with the highest *G. ruricola* roadkills in 2017 (Chapter 4)……….…………...157

ABSTRACT OF THESIS

University of Central Oklahoma

Edmond, Oklahoma

NAME: Kinsey Nicol Tedford

TITLE OF THESIS: Population Structure and Reproductive Migration of Land Crabs on Grand Cayman Island

DIRECTOR OF THESIS: David Bass, Ph.D.

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ABSTRACT: *Cardisoma guanhumi* (white land crab) and *Gecarcinus ruricola* (black land crab) are found throughout Grand Cayman, and concern has been expressed regarding their possible declining populations and current distributions. The overall objective of this project was to gather biological data on *C. guanhumi* and *G. ruricola*, as well as document activity patterns for *G. ruricola* populations, to gain a better understanding of Grand Cayman's land crab population structure and reproductive migration patterns. Surveys occurred during the summers of 2016 and 2017 on Grand Cayman. The study area for *G. ruricola* was along a main highway in East End, while the study site for *C. guanhumi* took place at Barkers National Park, West Bay. A male-biased sex ratio was observed in the *C. guanhumi* population on Grand Cayman, specifically in the two larger carapace width size classes. Generally, *C. guanhumi* males reached a larger body size than females, which is a common trend in brachyuran crabs. Four color patterns were observed in *C. guanhumi* males and non-ovigerous females, while ovigerous females only displayed two of the patterns. The color patterns seem to be related to the development stage and maturity of the crab. *Gecarcinus ruricola* males also reach a larger maximum size than females, for all measured morphometrics on Grand Cayman. Similar to *C. guanhumi*, these growth differences are likely due to how each sex distributes their energy utilization. Overall, both sexes of *G. ruricola* on Grand Cayman are smaller in terms of body size than other populations in the Caribbean and it may be possible the populations on Grand Cayman reach sexual maturity at an earlier stage and smaller size than other geographic locations. The reproductive migration season for *G. ruricola* extends over three months on Grand Cayman, but the intensity of crab activity varies with time. In 2017, high roadside activity levels for *G. ruricola* shifted from inland to the coastal edge of Queen's Highway following the first migration peak in June. There were two mass migrations observed with each resulting in high numbers of crabs crossing the road and high roadkill numbers. Crabs were not randomly scattered along the highway; instead each sex showed a distinct clustering distribution which most likely resulted due to habitat changes from development. Ovigerous *G. ruricola* females exhibited randomness during the reproductive season nights, and those random nights of ovigerous female activity most likely coincided with spawning events. The number of roadkills generally reflected the migration intensity. Moonlight had a significant effect on the number of *G. ruricola* individuals on the road, specifically during the waning crescent moon phase, and rainfall enhanced overall activity on Grand Cayman. This project will provide government officials with baseline information and methodology they can use to monitor Cayman's land crab populations in the future. Lastly, this study will provide a greater overall understanding of land crabs and their reproductive migration.

THESIS INTRODUCTION

There are many brachyurans often referred to as "land crabs," although in this context, land crabs will consist of members from the family Gecarcinidae. This family includes six genera: *Cardisoma*, *Discoplax*, *Epigrapsus*, *Gecarcinus*, *Gecarcoidea*, and *Johngarthia* (Hartnoll 1988a, Perger et al. 2011). All members of this family follow a similar life cycle where the majority of adult life is terrestrial and water dependence varies among species. All land crab eggs must be hatched in the sea, where the larvae undergo planktonic development (Hartnoll 1988a).

Land crabs occur on many islands throughout the tropics globally, where they are found in greatest numbers on low-lying terrain with densities often exceeding 1 crab/m^2 (Green 1997, Hartnoll 1988a). There are three gecarcinid species documented in the Caribbean: *Cardisoma guanhumi (*Latreille 1852), *Gecarcinus lateralis* (Fréminville 1835), and *Gecarcinus ruricola* (Linnaeus 1758) (Hartnoll et al. 2006, Baine et al. 2007).

Gecarcinus lateralis, the red land crab, occurs on Bermuda, the Bahamas, Florida Keys, West Indies, and along the Atlantic coast of Central America (Bliss 1978, Wolcott 1988). *Gecarcinus lateralis*' larger relative, the black or mountain land crab, *G. ruricola*, is mainly restricted to Caribbean Islands, the Bahamas, and from the western end of Cuba eastwards to Barbados (Hartnoll et al. 2006, Baine et al. 2007). *Cardisoma guanhumi*, often referred to as the white or blue land crab, is a circumequatorial species. This species is found on the east coast of America from Florida to southern Brazil, Bermuda, and Caribbean Islands (Gifford 1962, Wolcott 1988, Oliveira-Neto et al. 2014).

Of the gecarcinids, *Cardisoma* is the least tolerant of dry conditions and requires regular access to water to avoid desiccation (Gifford 1962, McMahon & Burggren 1988).

Specifically, *C. guanhumi* lives along the supratidal zone or around freshwater, within 5km from the coast (Gifford 1962, Herreid 1963, Hartnoll et al. 2006). This species can survive for multiple days in humid air, but only a couple days under severe desiccation (Gifford 1962). It is often found in mangroves, among fields of tall grass, in open hardwood groves, near muddy swamps, and sandy areas (Gifford 1962, Wolcott & Wolcott 1982). *Cardisoma guanhumi* is generally a burrower and requires regular access to water in which they can submerge themselves, either by frequently entering the sea, or by immersing in groundwater at the base of their burrow to avoid desiccation (Hartnoll 1988b, McMahon & Burggren 1988). Although *C. guanhumi* can remain submerged underground for long periods, heavy rains that naturally flood burrows appear to bring crabs to the surface (Lutz & Austin 1982). *Cardisoma guanhumi* juveniles are usually found in larger burrows belonging to conspecific adults (Wolcott 1988, Vannini et al. 2003).

Gecarcinus is the most terrestrial of the land crabs in the family Gecarcinidae. This genus occupies similar habitats to *C. guanhumi* and can also be found in damp and shaded forested areas where it burrows in the soil or shelters under rocks or tree roots (Hartnoll & Clark 2006, Hartnoll et al. 2006, Bass & Tedford 2015). While *Cardisoma* requires regular water immersion, *Gecarcinus* can obtain water from food, by drinking dew, or through osmotic uptake from damp substrates to avoid frequent water immersion (Wolcott 1976, Wolcott & Wolcott 1984a).

Cardisoma guanhumi and *G. ruricola* are mainly nocturnal, except during the reproductive season when large numbers may become active during the day. Regular nocturnal activity is stimulated by rainfall, but often inhibited by bright moonlight that is suspected to disorient or confuse them (Gifford 1962, Hounsome 1994, Hartnoll et al. 2006). *Gecarcinus lateralis* is primarily diurnal, although activity patterns vary based on geographic location (Bliss et al. 1978).

Morphological variation is observed in *G. ruricola*, *G. lateralis*, and *C. guanhumi*. *Gecarcinus ruricola* and *G. lateralis* show wide variations in their coloration patterns. Individuals may be a combination of black, purple, orange, or red. *Gecarcinus lateralis* is the smaller of the two species, possessing a squared carapace and four rows of spines or stiff black hairs on the walking legs. In contrast, *G. ruricola* has a rounder carapace and six rows of spines on the walking legs (Chace & Hobbs 1969, Hounsome 1994).

Cardisoma guanhumi displays different color patterns based on the animal's maturation and development stage (Gifford 1962, Silva et al. 2014). *Cardisoma guanhumi* juveniles (<40g in mass) often have darker coloration in comparison to adults and this may be a combination of dark brown, purple, or orange (Gifford 1962, Hostetler et al. 2003). Cryptic coloration may be more important early in life when post-settlement mortality is high, and survival at that stage determines recruitment and future population densities (Wolcott 1988, Palma & Steneck 2001, Vannini et al. 2003). Young crabs are exposed to a variety of predators, including larger conspecifics, and may benefit from visual crypsis (Gifford 1962, Hartnoll et al. 2009). As the individual grows, the carapace of *C. guanhumi* becomes lighter in coloration and will change to a combination of blue, lavender, and/or grey (Gifford 1962, Hostetler et al. 2003, Silva et al. 2014).

Gecarcinus ruricola, *C. guanhumi,* as well as a non-Caribbean species *Johngarthia lagostoma,* appear to be the largest of gecarcinids (Hartnoll et al. 2006). The maximum carapace (CW) for *G. ruricola* is unknown, but in a study by Hartnoll et al.

(2006), both sexes reached sexual maturity around 50mm CW. *Johngarthia lagostoma* reaches a maximum 120mm CW and *C. guanhumi* can have a maximum 150mm CW (Türkay 1970, Hostetler et al. 2003, Hartnoll et al. 2009). Because a major limitation on growth is obtaining water for post-molt expansion, most *Cardisoma* species void this constraint because they live near the supratidal zone or burrow down into the water table. Their readily access to water facilitates a larger molt increment, allowing them to reach a larger size (Green 2004, Hartnoll et al. 2009). Additionally, it has been observed that *J. lagostoma* females often reach a smaller size than males because they expend greater resources on reproduction, at the expense of growth (Hartnoll et al. 2009).

Cardisoma guanhumi females generally change color from blue to yellowish-white around the first ovulation of the season, and the lighter color persists through the reproductive season (Gifford 1962). Hartnoll et al. (2009) suggested the lighter coloration may be an adaptation to heat stress during ovulation because females are exposed to sunlight more during migration.

Land crab reproductive cycles are programmed largely in accordance with cues received from environmental factors, such as food and water availability, temperature, salinity, lunar phases, rainfall, tidal cycles, and competition between species (McDowall 1969, Adiyodi 1988, Adamczewska & Morris 2001). Baine et al. (2007) found that peak migrations in *G. ruricola* were related to lunar phases, but were more strongly influenced by rainfall. In *Cardisoma hirtipes*, spawns occurred three or four days before full moons, while in *G. lateralis*, spawning occurred four or five nights succeeding full moons in July and August (Wolcott & Wolcott 1982, Foale 1999). A study on Christmas Island indicated the spawning date of *Gecarcoidea natalis* was fixed by lunar phases, but late seasonal rains prompted a “rushed” migration where the crabs walked directly to their shore destinations (Adamczewska & Morris 2001). Spawning migrations are common in land crabs that move down to the sea for brood release and several spawns per year may occur, depending on onset of seasonal rains and locality (Baine et al. 2007). Mass migration occurrences have been documented in *Gecarcinus*, *Cardisoma*, *Gecarcoidea*, and *Johngarthia* species (Gifford 1962, Johnson 1965, Bliss et al. 1978, Adamczewska & Morris 2001, Hartnoll & Clark 2006, Hartnoll et al. 2009).

For the first few weeks of the reproductive season, foraging intensity increases, crabs rapidly gain weight, and males actively court females (Adiyodi 1988). After successful copulation has occurred, the female crab carries fertilized eggs on the bottom of her abdomen for an allotted incubation time before migrating to the ocean to spawn. The egg mass carried below a *C. guanhumi* female may contain up to 700,000 eggs (Lutz & Austin 1982). Fecundity in *C. guanhumi* is often related to body mass; a 300g female may produce 300,000 to 700,000 eggs per spawning. When the eggs are first deposited, the egg mass is black, compact, and shiny. As development proceeds, it becomes loose and ragged, and light brown in color. By this time, the embryos have reached the pre-zoea or zoea stage. In *C. guanhumi*, females carry the fertilized eggs for approximately two weeks before migrating to the ocean to spawn (Gifford 1962, Hostetler et al. 2003). In the laboratory, *G. lateralis* females remained within a closed burrow while carrying their developing eggs for 15 to 16 days. Between egg-laying and hatching, the female may produce 20,000 to 100,000 eggs according to the size of the crab. Eggs in *G. lateralis* will change in color from dark brown through yellow-brown to gray during embryo development (Klassen 1975, Bliss et al. 1978). Minimal information exists on the egg development process in *G. ruricola*, although estimated egg numbers ranged from 18,000 to 213,000 on females measuring 53 to 86mm CW (Hartnoll et al. 2007).

Cardisoma guanhumi and *G. lateralis* have unique physiological and behavioral strategies for minimizing water loss during recruitment. The eggs of *C. guanhumi* are euryhaline, allowing osmoregulation at low salinities. This is important as the crab's eggs are carried on the bottom of the abdomen, allowing exposure to water-filled burrows and brackish water during their migrations to the sea (Henning 1975, Wolcott & Wolcott 1982). The distance an ovigerous female, specifically *C. guanhumi*, travels to spawn usually occurs within 48 hours of leaving their burrow, so the egg mass is less likely to disintegrate (Gifford 1962). Females of *G. lateralis* must shake off their larvae within 10 hours of leaving their burrow, most likely for similar reasoning noted in *C. guanhumi* to avoid desiccation from ambient heat. Additionally, the developing eggs are also protected from rain inside the burrow because excessive water exposure can cause premature egg swelling (Klaassen 1975, Bliss et al. 1978). By remaining in a closed burrow, Klaassen (1975) concluded that such a narrow time span for larvae release prevents long spawning migrations to the sea (Gifford 1962, Wolcott & Wolcott 1982). Furthermore, *G. lateralis* has also been reported to migrate early with unripe eggs and stay in burrows near the shoreline until individuals are ready to spawn (Wolcott & Wolcott 1982).

The process of brood release has been studied in some detail in *G. lateralis*. Upon spawning, the female stands high on her legs as she approaches the tide to raise and retract her abdomen, permitting the first free-swimming zoea larvae to be washed off (Klassen 1975, Bliss et al. 1978, Adiyodi 1988). After drifting at sea for approximately 20 days and passing through five to six zoeal stages, the megalop returns to shore

(Hartnoll & Clark 2006). Because the young must emerge on land as megalops larvae (brachyurans display direct development), they are limited in distribution to the coast and its surrounding environment within tropical areas of the world (Bliss 1979, Adiyodi 1988). During the landward migration, it is crucial that suitable terrestrial habitats remain because the megalops of *Gecarcinus* and *Johngarthia* migrates inland into coastal forests (distance of >0.1km) before molting to the first crab instar. This is unique to other gecarcinid species where the molt to the first instar occurs in the water, or in moist adjacent habitats (Hartnoll et al. 2014).

Although gecarcinids are said to be the best land colonizers among decapods, fish predation and fluctuating currents may influence recruitment success (Wolcott 1988, Green 1997, Vannini et al. 2003). Island dwelling land crabs generally show irregular recruitment patterns due to the uncertainty of return to a small land mass after the planktonic larval phase (Hartnoll & Clark 2006). Additionally, the smaller and more isolated the island, the decreased chance of megalop recruitment success (Baine et al. 2007). If the shore is calmer on one side of the island than the other, the larvae will most likely have a better chance of landing ashore in the calmer area (Adamczewska & Morris 2001).

Cardisoma guanhumi and *G. ruricola* are found throughout the Cayman Islands (Chace & Hobbs 1969, Britton et al. 1982, Hounsome 1994). Both species are omnivores, feeding on leaf litter, fruits, and carrion, but will occasionally exhibit cannibalistic behaviors (Herreid & Gifford 1963, Wolcott & Wolcott 1984b, Dunham & Gilchrist 1988). During the dry season, these two species remain relatively inactive in burrows or their associated retreats, but seasonal rains usually beginning in May initiate migration and the reproductive season on Grand Cayman. This is not unexpected because high humidity levels increase crab foraging and migration (Adamczewska & Morris 2001). This has been observed in the red crab *G. natalis*; when humidity levels were lower, they retreated in their burrow where a favorable microclimate existed. Some individuals plugged their burrow entrance with a loose wad of leaves in exceptionally dry conditions (Green 1997). The only predators to *G. ruricola* and *C. guanhumi* on Grand Cayman are humans, although birds and feral cats/dogs will occasionally scavenge on dead crabs.

Different habitats for *C. guanhumi* and *G. ruricola* were presumed on Grand Cayman during a preliminary study in 2015, with *C. guanhumi* being more prominent in West Bay and *G. ruricola* more commonly seen in East End (Bass & Tedford 2015). It seemed *G. ruricola* was found in greater densities further inland among dry forests and rocky areas, while *C. guanhumi* abundances were higher along the coastline, among substrates of sand supporting mangrove forests. However, mixed populations of each species were found in both habitats and locations on Grand Cayman (Wolcott 1988, Bass & Tedford 2015). Possible reasons for species preferred habitat are due to each species' water tolerance (Wolcott 1988).

The Cayman Department of Environment (DoE) suspects land crab populations are declining across the island due to increases in vehicular traffic, habitat loss, overexploitation (*C. guanhumi* and *G. ruricola* are harvested for human consumption on Grand Cayman, although *G. ruricola* seems to be consumed on a smaller scale), and isolation from resources such as food, shelter, and potential mates (Cottam et al. 2009, Cayman Department of Environment pers. comm.).

Despite the ecological and economic interest of both land crab species, there have been no comprehensive studies undertaken in the Cayman Islands. The overall objective of this project is to gather biological data on *C. guanhumi* and *G. ruricola*, as well as document activity patterns for *G. ruricola* populations, to gain a better understanding of Grand Cayman's land crab population structure and reproductive migration. Chapter two focuses on the size composition and population characteristics of *C. guanhumi*, with regard to sex ratio, size frequency distribution in terms of body size, chela length, and color patterns. Chapter three includes interpreting morphometrics for both sexes of *G. ruricola* and conducting vegetation surveys to obtain a description of the species' habitat on the island. Lastly, chapter four discusses the coastal migration of *G. ruricola* by determining activity levels, describing the distribution of the migrating population temporally and spatially, noting mass migrations of ovigerous *G. ruricola*, estimating vehicular-caused mortality rates, and discussing *G. ruricola* activity patterns in relation to environmental factors. The knowledge gained from this study will be of value to environmental biologists and resource managers, especially those on Grand Cayman. This data will be shared with Cayman DoE to provide baseline information and methodology they can use to establish a conservation plan and monitor Cayman's land crab populations in the future. Lastly, this study will contribute to the growing body of knowledge involving land crab biology and their reproductive migration.

The research presented in the next three chapters are each formatted as papers for publication in two different journals. Chapters two and three are formatted for submission to *Caribbean Journal of Science* and chapter four will be submitted to the *Journal of Crustacean Biology*.

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SIZE COMPOSITION AND POPULATION CHARACTERISTICS OF THE WHITE LAND CRAB, *CARDISOMA GUANHUMI*, ON GRAND CAYMAN ISLAND

Kinsey Tedford

Department of Biology, University of Central Oklahoma, Edmond, OK, 73034

ABSTRACT

Despite the wide distribution of *Cardisoma guanhumi* (white land crab) throughout coastlines of Central and South America and the Caribbean, there have been no comprehensive studies undertaken on this species in the Cayman Islands. The objectives of the study are to describe the size composition and population characteristics of *C. guanhumi* on Grand Cayman, with regard to sex ratio, size frequency distribution, and color patterns. Individuals were collected from mid-May to August in 2016 at Barkers National Park, Grand Cayman. Various morphometrics and characteristics were recorded from 270 crabs. Sex ratios significantly differed from an expected 1:1 (male:female) ratio. There were a higher number of males than females observed in the *C. guanhumi* population sampled, specifically in the two larger carapace width size classes. Generally, males reached a larger body size than females for all measured morphometrics, which is a common trend in brachyuran crabs. These growth differences are associated with how each sex allocates energy expenditure. Although *C. guanhumi* is heterochelic, there was no significant differences in handedness preference. Four color patterns were observed in *C. guanhumi* males and non-ovigerous females, while ovigerous females only displayed two of the patterns. The color patterns seem to be related to the development stage and maturity of the crab.

Keywords: Gecarcinidae, Cayman Islands, Crustacea

INTRODUCTION

The white land crab, *Cardisoma guanhumi* (Latrielle 1828) is a brachyuran belonging to family Gecarcinidae (Hartnoll 1988a). This species displays a wide distribution throughout tropical and estuarine regions from Florida to southern Brazil, including Bermuda, Central America, South America, and the Caribbean (Gifford 1962, Wolcott 1988, Oliveira-Neto et al. 2014, Silva et al. 2014).

As adults, *C. guanhumi* is semi-terrestrial inhabiting areas near water, such as muddy shorelines, mangrove swamps, forests, and low-lying areas with brackish ponds (Gifford 1962, Wolcott 1988, Oliveira-Neto et al. 2014). *Cardisoma guanhumi* constructs and inhabits burrows made of sand and mud, which usually extend down to groundwater (Wolcott 1988, Moraes-Costa & Schwamborn 2018). As a herbivore-detritivore, *C. guanhumi* feeds on leaves, fruits, carrion, and will occasionally exhibit cannibalistic behaviors (Herreid 1963, Dunham & Gilchrist 1988).

Currently, *C. guanhumi* faces several threats such as habitat loss, vehicular traffic, and overharvesting, as this species often serves as a source of income and food for humans (Cottam et al. 2009, Moraes-Costa & Schwamborn 2018). In areas where *C. guanhumi* is exploited as a food source, such as the Bahamas and Caribbean Islands, it is imperative to gather rigorous data to determine population trends and develop conservation plans, if necessary (Hostetler et al. 2003, Shinozaki-Mendes et al. 2013, Moraes-Costa & Schwamborn 2018).

Cardisoma guanhumi has been fairly well-studied across its geographic range. However, no comprehensive studies on *C. guanhumi* have been undertaken in the Cayman Islands and the species occurs on all three islands (Hounsome 1994, Cayman Department of Environment pers. comm.). The objectives of the study are to describe the size composition and population characteristics of *C. guanhumi* on Grand Cayman, with regard to sex ratio, size frequency distribution in terms of body size, chela length, and color patterns. This study will be used in assessing the current status of the population, as much of the information is related to development stages and sexual maturity of the animal (Gifford 1962, Silva et al. 2014). *Cardisoma guanhumi* is suspected to be in declining numbers on Grand Cayman, thus it is essential to conduct this study for the proper management of this species (Cottam et al. 2009, Cayman Department of Environment pers. comm.).

METHODS

Study area

Sampling was conducted at Barkers National Park (19° 23’ 16.6’’ N, 81° 22’ 7.3’’ W), located at the tip of the West Bay peninsula on Grand Cayman (Fig. 1). Barkers is a somewhat isolated and undeveloped area on the northwest coast of Grand Cayman and includes 241 acres of land. The habitat consists of tidally flooded mangrove forest and woodlands, coastal shrublands including seagrape, salt-tolerant succulents, and brackish ponds (DaCosta-Cottam et al. 2009; Fig. 2). This study area was selected based on high densities of *C. guanhumi* observed during a preliminary study in May 2015 and advice from the Cayman Department of Environment.

Grand Cayman has a mean annual temperature of 27.9°C and mean monthly precipitation of 118.96mm per year. However, during the rainy season (May to late October, Burton 1994), there are increases in the mean temperature (29.2°C) and mean precipitation during that time (174.5mm). Relative humidity levels range from 76 to 79% year-round (National Oceanic and Atmospheric Sciences, https://www7.ncdc.noaa.gov/CDO/cdoselect.cmd?datasetabbv=GSOD). It should be mentioned that rainfall increases from east to west across Grand Cayman due to prevailing winds carrying cloud masses over the island. Additionally, the extensive mangrove wetlands in West Bay results in localized rainfall caused by the formation of rain clouds from the high evaporation rates during the summer heat (Burton 1994).

Data collection

Cardisoma guanhumi specimens were collected by hand throughout Barkers from mid-May to early August in 2016. A preliminary study in 2015 indicated crab activity was highest following dusk, thus sampling occurred during this time (2000 and 2100). The following characteristics and morphometrics were obtained for each individual: sex, ovigerous/non-ovigerous status, color pattern, mass (g), carapace width (CW) (mm), and major chela length (mm). Sex was determined by abdominal shape for all crabs and the presence of eggs was noted on females. Identifying sex based on the presence/shape of the abdominal appendage groove has been shown to be a reliable method in other brachyurans (*Callinectes sapidus* and *Rhithropanopeus harrissi*) when the individual has molted through the first two post-larval stages (Adiyodi 1988). Color was categorized based on the descriptions presented by Gifford (1962) and Silva et al. (2014), with minor modifications to the color morphs observed in this study because individuals seem to vary based on geographic location (Fig. 3). Color patterns are classified as follows: pattern 1 – characteristic for the juvenile stage, when the dorsal carapace is brown and the legs are a combination of orange, brown, and/or yellow; pattern 2 – referred to as the transition stage between juvenile and adult, distinguished by a brown body (lighter than the brown in pattern 1) with hints of green and yellow tones throughout the dorsal carapace; pattern 3 – represents individuals with a blue and grey carapace with hints of yellow and green; pattern 4 – characterized by purple and/or grey carapace and legs. Major chela length was determined by measuring the larger chela (dactyl and propodus) and noting the handedness, whether it was on the right or left first pereopod of the crab. Morphometrics were taken using a digital caliper to the nearest millimeter and a pesola macroline spring scale to the nearest gram.

Statistical analyses

Sex ratios in each class of carapace width were analyzed based on an expected 1:1 (male:female) ratio through a chi-square test χ^2 (Zar 1999). Fisher's Exact Test was used in classes where the number of individuals were between 10 to 20 and the expected frequencies were less than 10 (Agresti & Kateri 2011). A binomial distribution was used to calculate probabilities when the number of individuals was less than 10 for each size class (Conover 1971). Morphometric data (mass, carapace width, and major chela length) were tested for normality using the Shapiro-Wilks test and homoscedasticity using

Levene's F-test. Based on those results, differences between morphometric characteristics were analyzed with a Mann-Whitney U test or an independent *t*-test. Handedness deviating from an expected 1:1 (right:left) ratio was tested through a chi-square test χ^2 or Fisher's Exact Test. Based on *a priori* tests of normality using Shapiro-Wilks tests and homogeneity of variances through a Bartlett test, a Kruskal-Wallis ANOVA was used to analyze whether the color pattern reflects significant differences in the carapace width size of *C. guanhumi* males and females. When significant effects were detected in the Kruskal-Wallis ANOVA, Conover's *post hoc* tests were applied *a posteriori* to those results (Conovar & Iman 1979). A significance level of 0.05 was chosen for all analyses and statistics were performed using the program R (v. 3.4.2; R Core Team 2017).

RESULTS

A total of 270 *C. guanhumi* individuals were captured comprising 167 (61.9%) males and 103 (38.1%) females (non-ovigerous=88 individuals (32.6%), ovigerous=15 individuals (5.5%)), with a sex ratio differing significantly from an expected 1:1 (χ^2=15.17, df=1 p<0.0001). The sex ratio by carapace width (CW) size classes differed significantly from the expected 1:1 in the 60.0 to 65.0mm CW (χ^2=7.2, df=1, p=0.0073) and 80.0 to 85.0mm CW (χ^2=5.48, df=1 p=0.0192) size classes (Fig. 4). In the 50.0 to 55.0 mm CW size class, the probability of obtaining a 1:7 ratio was estimated as 12.5% (95% CI, [0.3%, 52.6%]) (Binomial test, one-tailed, p=0.0703). Carapace width size classes with two individuals or less were not statistically analyzed due to small sample sizes.

Table 1 provides a detailed summary of mass, carapace width, and major chela length values obtained for both sexes of *C. guanhumi*, as well as handedness ratios. There was a significant difference in mass (Mann-Whitney U test, U=7204.5, p=0.0251) and major chela length (Mann-Whitney U test, U=4644.5, p<0.0001) between *C. guanhumi* males and females. Carapace width did not significantly differ between males and females (Mann-Whitney U test, U=8209, p=0.5294). When comparing morphometrics between non-ovigerous and ovigerous females, there were significant differences in mass (Mann-Whitney U test, U=399, p=0.0148), carapace width (*t*-test , t=-3.89, df=20, p=0.0008), and major chela length (Mann-Whitney U test, U=378, p=0.0085). Males (χ^2=1.347, df=1 p=0.2457), non-ovigerous females (χ^2=0, df=1 p=1), and ovigerous females (Fishers Exact Test, p=0.7224) did not significantly differ from the expected 1:1 handedness ratio. The largest major chela (138.2mm) was recorded from a male with a mass of 575g and 104.9mm CW.

All four color patterns were observed in males and non-ovigerous females, while ovigerous females only displayed the second and third patterns (Fig. 5). Pattern one was present in males varying from 15.5 to 86.6mm CW (n=31) and non-ovigerous females from 49.5 to 88.0mm CW (n=22). Pattern two was present in males varying from 54.2 to 104.9mm CW (n=84), non-ovigerous females from 54.0 to 106.0mm CW (n=59), and ovigerous females 68.9 to 96.2mm CW (n=13). Pattern three was present in males varying from 64.0 to 98.9mm CW (n=39), non-ovigerous females from 71.3 to 73.0mm CW (n=3), and ovigerous females 72.7 to 86.4mm CW (n=2). Pattern four was present in males varying from 64.0 to 98.3mm CW (n=13) and non-ovigerous females from 76.4 to 81.3mm CW (n=4).

Color patterns were analyzed with Kruskal-Wallis ANOVA tests for *C. guanhumi* male and female carapace width values (n=270). Ovigerous and non-ovigerous females were combined into one category for statistical analyses due to ovigerous females having a small sample size (n=15) and only displaying two of the four color patterns. Carapace width values varied significantly among color patterns in males (Kruskal-Wallis ANOVA, χ^2=38.174, df=3, p<0.0001) and females (Kruskal-Wallis ANOVA, χ^2=17.782, df=3, p=0.0004). For males, differences in carapace width sizes occurred between patterns one and two (Conover *post hoc* test, p<0.0001), one and three (Conover *post hoc* test, p<0.0001), and one and four (Conover *post hoc* test, p=0.0002). Females displayed a significant difference in carapace width values between color patterns one and two (Conover *post hoc* test, p=0.0003).

DISCUSSION

The Fisher theory suggests a sex ratio of 1:1, however, the results of this study indicated the *C. guanhumi* population sampled differed significantly from that ratio (Fisher 1930, MacArthur 1965). The differences occurred specifically in two of the larger size classes, 60.0 to 65.0mm and 80.0 to 85.0mm CW, which both presented a higher number of males than females. A male-biased sex ratio has also been seen in *C. guanhumi* in Brazil, as well as other species of brachyurans such as *Macrophthalmus grandidieri*, *Sesarma meinerti*, and *Uca pugilator* (Emmerson 1994, DeRivera 2003, Johnson 2003, Silva et al. 2014), but this ratio seems to be unexpected in *C. guanhumi* (Shinozaki-Mendes et al. 2013). Populations may differ from the expected 1:1 ratio for several reasons such as species type, year, geographic location, food supply, predation pressure, sex-specific habitat use, mortality, and differential growth rates (Wenner 1972, DeRivera 2003, Johnson 2003, Diele & Koch 2010, Silva et al. 2014). In the present study, the male-biased sex ratio was most likely influenced by the sampling methodology, as well as the water tolerance, behavior, and sex-specific habitat use in *C. guanhumi*.

Of the gecarcinids, *Cardisoma* is the least tolerant of dry conditions and requires regular access to water to avoid desiccation. This requires the species to remain close (within several square meters) to their burrows or near a water source (Herreid 1963, Wolcott 1988). Additionally, Herreid (1963) noted when *C. guanhumi* was foraging, it either immediately ate the food item or quickly moved to the burrow with the object in hand. Based on this information and personal field observations, it seems this species has a very quick detection to noise and vibrations in the ground, thus any sudden movement towards the animal will trigger an immediate escape response into any nearby burrow and/or crevice (Dunham & Gilchrist 1988). Furthermore, each sex may have a different preference for habitat type depending on the time of the year and environmental conditions. The reproductive season for *C. guanhumi* varies based on geographic location within its range, but it seems to start around the onset of the rainy season and extend for several months (Gifford 1962). The rainy season on Grand Cayman can broadly be categorized from May to October (Burton 1994). Adult males are often more active during the reproductive season attempting to court a female or out foraging, while females tend to spend prolonged periods underground conserving energy for reproductive purposes (Montague 1980, Johnson 2003). Moreover, it is possible during a critical time such as the reproductive season, females remained in their burrows to avoid unnecessary exposure to heat and predators, which led to a skewed sex ratio in this study.

Sexual differentiation has been studied in at least four brachyuran species (*Callinectes sapidus*, *Carcinus maenas*, *Rhithropanopeus harrissii*, and *Menippe mercenaria*) revealing that reproductive systems remained undifferentiated through embryonic and larval stages (Payen 1974, Adiyodi 1988). These results suggest environmental factors such as water temperature, nutrient availability, and salinity potentially influence sex determination during zoeal stages (Jaccarini et al. 1983, Adams et al. 1987, Sgro et al. 2002). Furthermore, the sex determining system in a brackish water crustacean (*Gammarus duebeni*) was linked to the species' existing population dynamics (Naylor et al. 1988). Similarly, it is possible the current population structure of *C. guanhumi* on Grand Cayman has the potential to influence the newly settled larvae in their establishment and sex ratio outcomes.

There were also a small number of individuals <50mm CW collected and this may also be due to different habitat preferences for juvenile crabs. Juveniles are less tolerant to environmental extremes than adult crabs, thus remaining underground in a humid habitat would be advantageous to avoid dry conditions, as well as predators (Gifford 1962, Wolcott & Wolcott 1988, Diele et al. 2005, Hartnoll et al. 2009). The collecting methods from this study focused on surface sampling and did not incorporate burrow sampling, or temporal and spatial variability, which may have been possible reasons leading towards the lack of juveniles.

Overall, *C. guanhumi* males sampled on Grand Cayman reach a larger maximum size than females, for all measured morphometrics. Almost all of the females were

<97.0mm CW, except for the largest individual sampled in this study which was a non-ovigerous female with a mass of 400g, 106.0mm CW, and major chela length of 81.9mm. In brachyurans, the larger size of males is due to the longer period of somatic growth and a larger increase in size during molting — *C. guanhumi* molts several times annually and may live up to 13 years (Hartnoll 1988b, Wolcott 1988, Johnson 2003). In addition, the slower growth rate of female crabs is often associated with the greater amount of energy invested in reproductive activities (Hartnoll 1988a).

The size *C. guanhumi* reaches at sexual maturity varies considerably and has been estimated by carapace width, mass, and gonad development (Gifford 1962, Adiyodi 1988, Shinozaki-Mendes et al. 2013, Silva et al. 2014). In this study, ovigerous females ranged from 68.9 to 96.2mm CW and 160 to 420g in mass. It seems growth rates and their associated physiological changes vary among locations and factors such as salinity and food availability may determine the size at first maturity (Silva et al. 2014). *Cardisoma guanhumi* is heterochelic (when one claw is larger than the other), without preferential handedness (Gifford 1962) which was supported in this study. Changes in the chela size and structure influence crab social behavior (e.g., fighting, signaling, attracting mates) and most likely become more prominent and important as the individual reaches sexual maturity (Herreid 1967, Hartnoll 1982).

Color patterns often change with skeletal growth, seasonality, changes in osmoregulation, and respiratory physiology (Reid et al. 1997, Silbiger & Munguia 2008, Silva et al. 2014). These color morphs are obtained by different pigment combinations embedded in the carapace and chromatophores found in the epidermis (Gifford 1962). In *C. guanhumi*, color patterns are related to the maturity and the development stage

(Gifford 1962, Silva et al. 2014). The most common color pattern for both sexes observed in this study was color pattern two, which is characteristic of a transitional stage from juvenile to adult in *C. guanhumi*. The female adult color pattern related to ovulation (white, yellow, and/or grey carapace) described by Gifford (1962) was absent from this study. It may be possible it was too early in the reproductive season to observe these color changes, or females do not achieve this color pattern on Grand Cayman.

Summary & Conclusion

A male-biased sex ratio was observed in the *C. guanhumi* population sampled on Grand Cayman, specifically in the two larger carapace width size classes. The higher number of males was most likely influenced by the surface sampling methodology, as well as the water tolerance, behavior, and sex-specific habitat use in *C. guanhumi*. Additionally, environmental factors may have also played a role in sexual differentiation and the outcome of sex ratios during the larval stages. Generally, males reached a larger body size than females, which is a common trend in brachyuran crabs. These growth differences are due to how each sex allocates energy expenditure. *Cardisoma guanhumi* is heterochelic, but there was no preferential handedness observed in the study. Four color patterns were observed in males and non-ovigerous females, while ovigerous females only displayed the second and third patterns. The color patterns seem to change as *C. guanhumi* individuals increase in body size. Significant differences were seen between the first pattern, which is often associated with the juvenile stage, and the other three color patterns observed on larger individuals, based on carapace width.

Future studies would benefit from incorporating other crab collection methods such as baited traps within the burrow/retreats to obtain an extensive depiction of sex ratios and color pattern variations. Additionally, experiments involving the reproduction and development of *C. guanhumi* would yield valuable information in regards to sex differentiation and determination in crustaceans. Lastly, comparable studies would be useful on Little Cayman and Cayman Brac, as these islands are less developed and have habitats similar to those sampled at Barkers on Grand Cayman.

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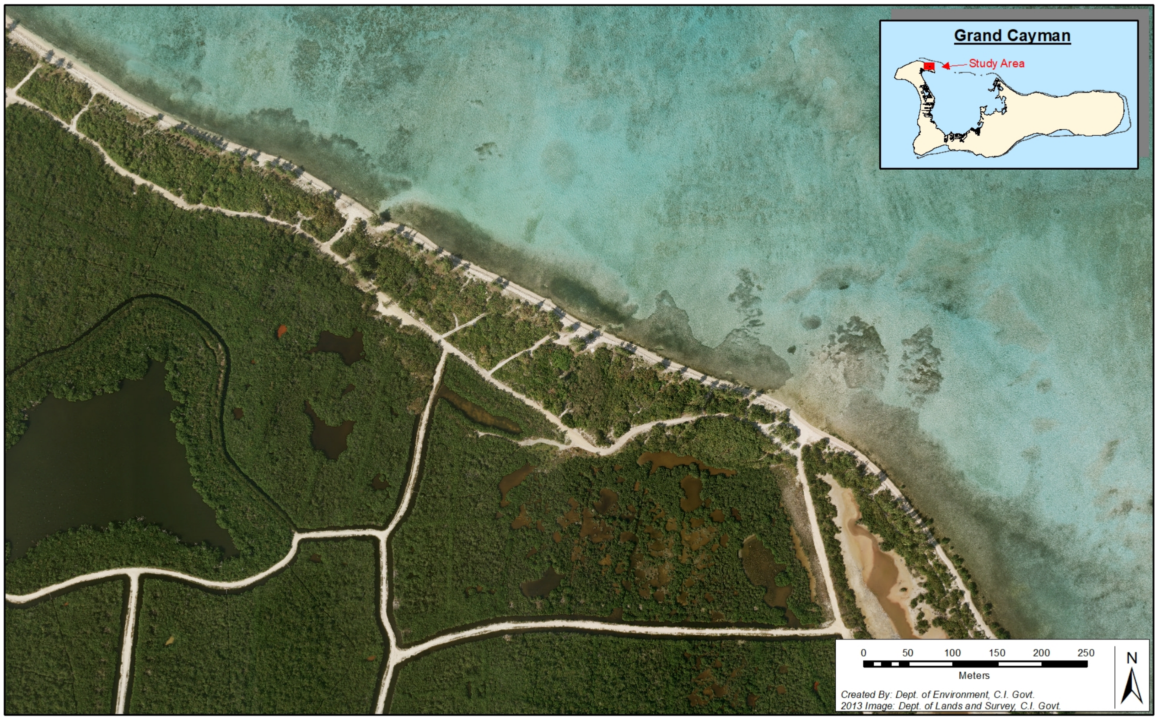

Figure 1. Map displaying the study area within Barkers National Park, West Bay, Grand Cayman. Map created by the Department of Environment, Cayman Islands Government, March 2018.

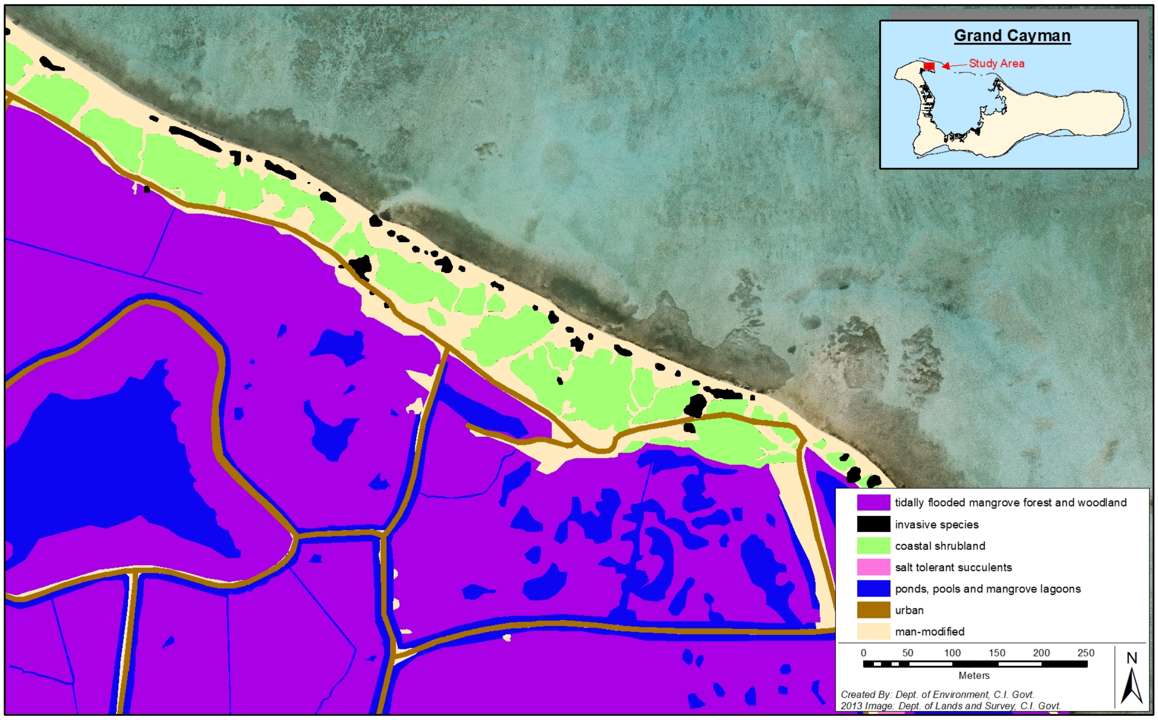

Figure 2. Map displaying the study area within Barkers National Park, Grand Cayman illustrating land use/land cover classifications. Map created by the Department of Environment, Cayman Islands Government, March 2018.

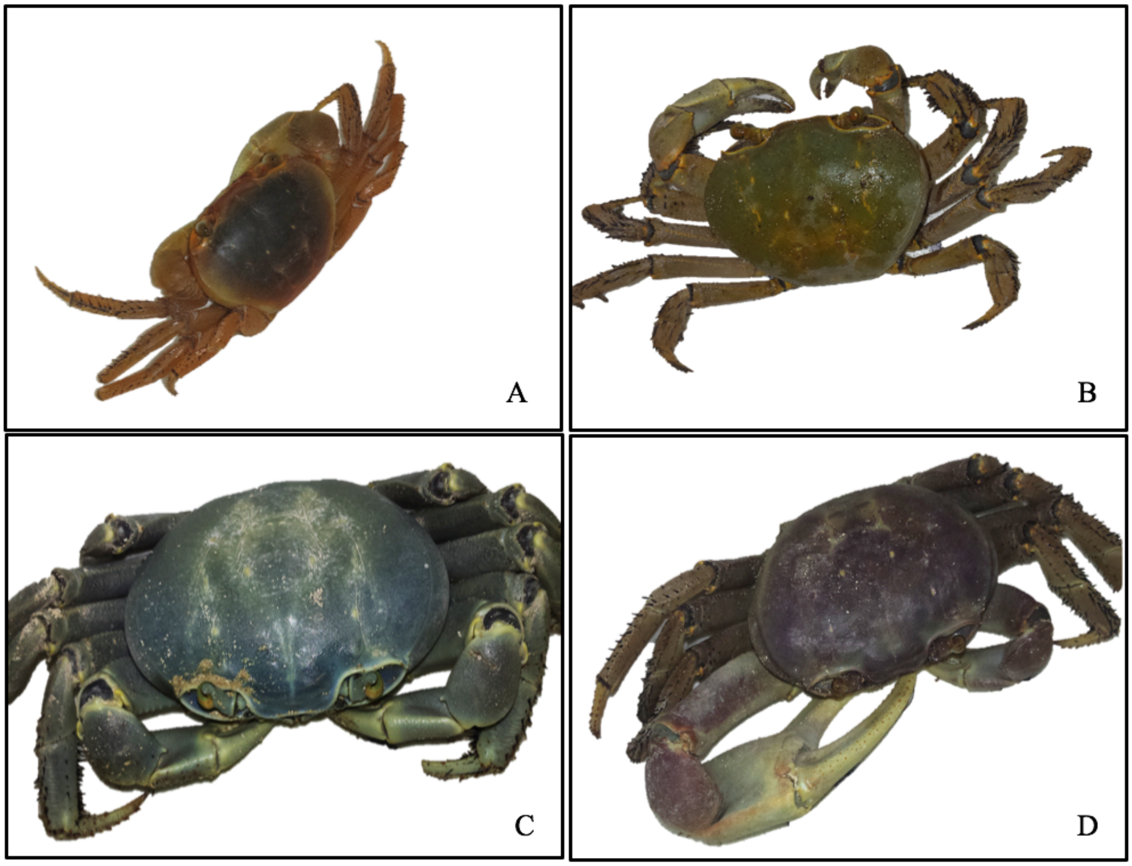

Figure 3. *Cardisoma guanhumi* color patterns documented at Barkers National Park, Grand Cayman from mid-May to early August in 2016. A) Pattern 1; B) Pattern 2; C) Pattern 3; D) Pattern 4. Specific descriptions of color categories are presented in the methods. **photos are not to scale*

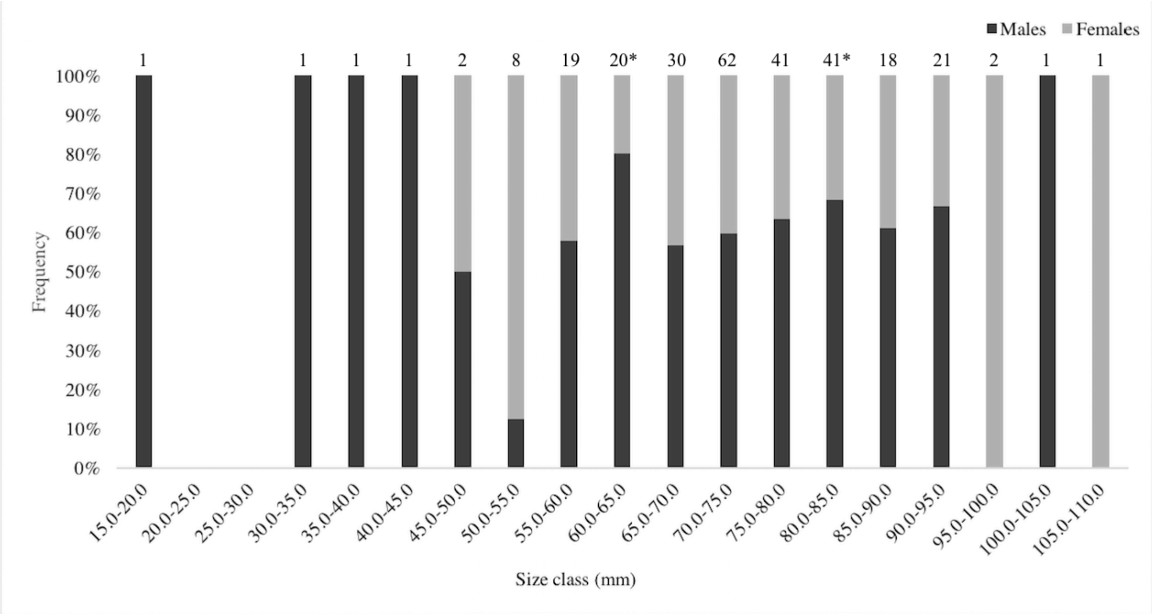

Figure 4. Sex ratio of *C. guanhumi* males and females by carapace width (mm) size class, sampled at Barkers National Park, Grand Cayman, from mid-May to early August in 2016. The sample size is denoted at the top and an asterisk (*) indicates statistical significance differing from an expected 1:1 (male:female) ratio (Fisher 1930). Carapace width size classes with two individuals or less were not statistically analyzed due to small sample sizes.

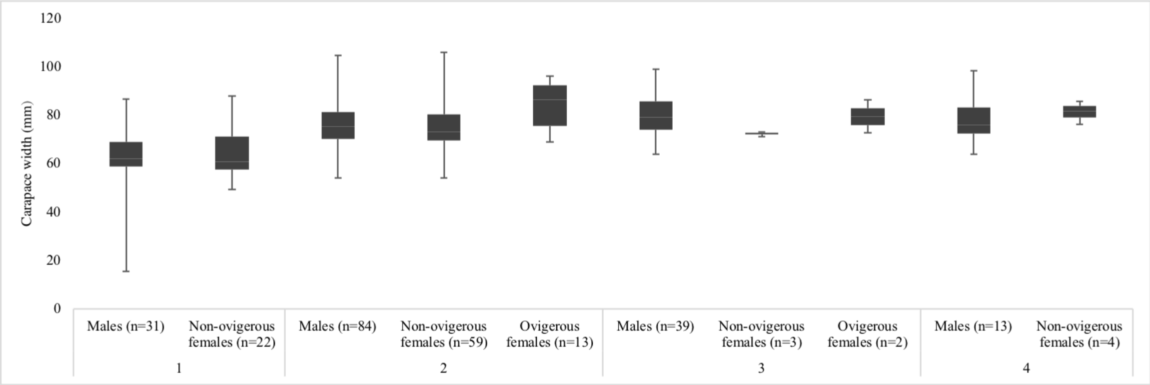

Figure 5. Carapace width (mm) ranges for *C. guanhumi* males, non-ovigerous females, and ovigerous females in relation to the four color patterns sampled at Barkers National Park, Grand Cayman from mid-May to early August in 2016.

Table 1. Morphometrics and handedness ratios for data collected on *C. guanhumi* from mid-May to early August in 2016 at Barkers National Park, Grand Cayman (n=270) [median ± standard error (min-max)].

Mass (g)	Carapace width (mm)	Major chela length (mm)	Handedness (Right:Left)
Males (n=167)			
225 ± 7.6 (5-575)	74.5 ± 0.9 (15.5-104.9)	72.2 ± 1.6 (7.7-138.2)	91:76
Non-ovigerous females (n=88)			
190 ± 7.5 (50-400)	72.8 ± 1.2 (49.5-106.0)	58.5 ± 1.2 (29.4-82.2)	44:44
Ovigerous females (n=15)			
285 ± 21.4 (160-420)	86.4 ± 2.5 (68.9-96.2)	65.6 ± 3.0 (43.1-79.6)	6:9

POPULATION STRUCTURE AND HABITAT DESCRIPTION OF THE BLACK LAND CRAB (*GECARCINUS RURICOLA*) ON GRAND CAYMAN ISLAND

Kinsey Tedford

Department of Biology, University of Central Oklahoma, Edmond, OK, 73034

ABSTRACT

The population structure and habitat preferences for *Gecarcinus ruricola* (black land crab) were studied on Grand Cayman because of the ecological and economic interests, as well as the limited amount of literature on this species in the Cayman Islands. Goals of the study included gathering and interpreting morphometrics for both sexes and describing the species' habitat during the 2016 and 2017 reproductive seasons. Vegetation surveys indicated the habitat of *G. ruricola* consisted of at least twenty-four dominant plant species distributed among various forms of calcareous rock formations. Morphometrics involving carapace/chela measurements and body mass were recorded from *G. ruricola* males, non-ovigerous females, and ovigerous females collected in East End, Grand Cayman. Results indicated there were significant differences in several morphometric characteristics between both sexes. Overall, individuals from this study were smaller than other *G. ruricola* populations in the Caribbean and it may be possible the populations on Grand Cayman reach sexual maturity at an earlier stage and smaller size than other geographic locations.

Keywords: Gecarcinidae, Cayman Islands, Crustacea

INTRODUCTION

Gecarcinus ruricola (Linnaeus 1758), commonly referred to as the black land crab, occurs primarily on Caribbean Islands (Hartnoll et al. 2007). This species' distribution is widespread throughout the Greater and Lesser Antilles, the Bahamas, and extends from the western end of Cuba eastwards to Barbados (Carson 1967). It has also been recorded from Curacao and throughout the western Caribbean on the Swan Islands (north of Honduras), and Old Providence and San Andrés Islands (east of Nicaragua) (Hartnoll et al. 2006, Baine et al. 2007).

In the Caribbean, *G. ruricola* is the most terrestrial of the land crabs in the family Gecarcinidae. It inhabits damp and shaded forested areas, where it burrows in the soil, or shelters under rocks or tree roots. It may be found considerable distances from the sea and at high altitudes (>300m) (Chace & Hobbs 1969, Hartnoll & Clark 2006, Hartnoll et al. 2006). *Gecarcinus ruricola* is mainly nocturnal, except during the reproductive season when high numbers can be active during the day. Their nocturnal activity is stimulated by rainfall, but inhibited by bright moonlight (Hartnoll et al. 2006). As an omnivorous scavenger, *G. ruricola* feeds mainly on decaying leaf litter, fruits, and carrion (Hartnoll et al. 2007).

Gecarcinus ruricola occurs on all three Cayman Islands (Britton et al. 1982, Hounsome 1994). There is a limited amount of literature on *G. ruricola*, especially on Grand Cayman. This is unexpected for within its range it is one of the most conspicuous terrestrial crustaceans. Studies within the Cayman Islands involving *G. ruricola* include: Carson (1967, 1974) describing the symbiotic relation with *Drosophila* flies, Vilela et al. (2008) re-describing the Cayman crab fly (*Drosophila endobranchia*), Stensmyr et al.

(2008) further examining the Cayman crab fly phylogeny and biology, and Britton et al. (1982) comparing *G. ruricola* biometry, distribution, and activity levels with the red land crab, *Gecarcinus lateralis*, throughout the Caribbean.

Due to the ecological and economic interests of *G. ruricola*, efforts were made to describe the population structure and habitat preferences of this species during the reproductive season on Grand Cayman. Goals of this study included gathering and interpreting morphometrics for both sexes and conducting vegetation surveys to obtain a description of the species' habitat on Grand Cayman.

METHODS

Study area

Preliminary studies were made in 2015 during the reproductive season to determine areas with the greatest *G. ruricola* densities. In addition to these observations and advice from the Cayman Department of Environment, the study site was selected to occur in East End, Grand Cayman. Specifically, on and alongside Queen's Highway, a major highway between North Side and Colliers Beach. The study area began at the Queen's Monument (19° 21' 8.6 N, 81° 8' 16.5'' W) and extended eastward 4km (19° 21' 10.4 N, 81° 7' 4.4'' W) (Fig. 1).

Morphometrics

In 2016 and 2017, *G. ruricola* specimens were captured by hand throughout the reproductive season from May to August. During 2016, mass (g), carapace width (mm), carapace length (mm), major chela length (mm), interorbital distance (minimum distance between orbits) (mm), and fronto-orbital distance (maximum distance between orbits) (mm) for each individual were recorded. In 2017, the only morphometric measured was carapace width. Mass was determined by a pesola scale to the nearest gram and measurements were obtained from a digital caliper to the nearest millimeter. Major chela length was determined by measuring the larger chela (dactyl and propodus) and noting the handedness, whether it was on the right or left first pereopod of the crab. If heterochely (when one claw is larger than the other) was not easily observed, an average of the right and left chela was recorded. Morphometric measurements proposed by Britton et al. (1982) were used as a reference. Furthermore, each crab was sexed and the presence of eggs was noted on females for both years of data collection. Sex was determined by abdominal shape for all crabs >10mm carapace width (CW); in crabs <10mm CW, the shape of the abdomen has not yet sufficiently differentiated between males and females to accurately sex the crab. All specimens were captured randomly on or along Queen's Highway each night (between 2000 and 2300), data were taken, and individuals were released unharmed. Sampling efforts were restricted to a catch limit of 10 individuals per night in 2016, while in 2017 all observed individuals were captured, allowing larger sample sizes to obtain a more accurate representation of the *G. ruricola* population on Grand Cayman.

Statistical analyses

Data were tested for normality using the Shapiro-Wilks test and homoscedasticity using Levene's F-test. Based on those results, differences between morphometric characteristics were analyzed with a Mann-Whitney U test (Bauer 1972). A significance level of 0.05 was chosen for all analyses and statistics were performed using the program R (v. 3.4.2; R Core Team 2017).

Habitat description

Due to the sparsity of literature describing the ecology of *G. ruricola* in the Cayman Islands, efforts were made to obtain a comprehensive description of the species' habitat in East End, Grand Cayman. Vegetation surveys were carried out in July 2017 along the same 4km stretch of Queen's Highway where the crab morphometric data were obtained. The study area was divided into 40 predetermined 500m^2 (5x100m) roadside sections, conveniently indicated by distance markers. The procedure was to walk through the sections and document the dominant plant species on the coastal and inland roadsides. A plant was considered "dominant" if it was present in at least 20% of the 40 sections. The surveys were limited to 5m from the road edge due to private property boundaries. Identification of flora was determined primarily using keys by Proctor (1984), Burton (2007), and Burton (2008). Furthermore, land cover and land use classification maps created by the Cayman Department of Environment were utilized for additional descriptive information (DaCosta-Cottam et al. 2009; Fig. 2).

RESULTS

In 2016, there were significant differences in mass (Mann-Whitney U test, U=2727.5, p<0.0001), carapace width (Mann-Whitney U test, U=4387.5, p <0.0001), and major chela length (Mann-Whitney U test, U=1046, p<0.0001) between both sexes (Table 1, Table 2, Fig. 3-6). When comparing ovigerous and non-ovigerous females in

2016, there were no significant differences in mass (Mann-Whitney U test, U=871.5, p=0.5475), carapace width (Mann-Whitney U test, U=973.5, p=0.84), or major chela length (Mann-Whitney U test, U=838.5, p=0.3951). Scatter plots were created to display the patterns of growth in carapace width and interorbital distance, as well as carapace width and fronto-orbital distance for both sexes (Fig. 7-10).

Based on the combined data in 2016 and 2017, there were significant differences in carapace width between males and females (Mann-Whitney U test, U=337070, p<0.0001), males and females excluding <10mm individuals (Mann-Whitney U test, U=268420, p<0.0001), ovigerous and non-ovigerous females (Mann-Whitney U test, U=186200, p<0.0018), and ovigerous and non-ovigerous females excluding <10mm individuals (Mann-Whitney U test, U=180000, p<0.0087). Box and whisker plots demonstrate the distribution and variability for *G. ruricola* carapace width values in relation to data collection year (Fig. 11). Heterochely was observed in 87.5% of males (86 individuals with right major chela and 77 individuals with left major chela), 42.9% of non-ovigerous females (16 individuals with right major chela and 18 individuals with left major chela), and 50% of ovigerous females (eight individuals with right major chela and four individuals with left major chela).

Twenty-four dominant plant species were identified along Queen's Highway, including trees, shrubs, weeds, grasses, and flowering plants bearing fruits (Table 3). Based on the land cover and land use classification maps, the study area consists of dry forests and woodlands, seagrape hedge, dry shrublands, sparsely vegetated rock, and man-modified land including: cleared land, public parks, private gardens, landscaped areas, farmland, and secondary growth (DaCosta-Cottam et al. 2009; Fig. 2, Fig. 12).

DISCUSSION

For the population of *G. ruricola* sampled within East End, Grand Cayman, males reach a larger maximum size than females, for all measured morphometrics. This is a common occurrence in land crabs of the family Gecarcinidae and has been recorded in all species examined to date. The slower growth rate of female crabs is associated with the greater amount of energy invested in the reproductive process, especially during their seaward breeding migration, at the cost of growth (Hartnoll 1988a).

The mean and median sizes for both sexes of *G. ruricola* in this study, as measured by carapace width, are consistent with values obtained from Britton et al. (1982) who examined *G. ruricola* individuals from the Gulf of Mexico, Florida/Bahamas, Central Caribbean (including the Cayman Islands), and Eastern Caribbean. Although, based on orbital distances and maximum carapace width values, Cayman *G. ruricola* are smaller than *G. ruricola* in other Caribbean regions (Britton et al. 1982). The orbital width becomes relatively smaller with size compared to carapace width in Britton et al. (1982), but the results from this study suggest the opposite (except in non-ovigerous females when comparing carapace width to interorbital distance).

Additionally, it has been suggested that *G. ruricola* individuals reach sexual maturity at >50mm CW (Hartnoll et al. 2007), although two individuals from this study were found bearing eggs which were both <50mm CW (21.8mm CW and 35.8mm CW). Sexual maturity in Hartnoll et al. (2007) was determined by egg and gonad development, concluding maturity occurred at approximately half of the maximum carapace width on individuals within islands of the San Andrés Archipelago, which is approximately

110mm CW (Hartnoll et al. 2006). The maximum carapace width for *G. ruricola* males was 98.0mm and 92.1mm for females on Grand Cayman.

The orbital and maximum carapace width measures, as well as the two exceptionally small ovigerous females, suggest the *G. ruricola* population on Grand Cayman reaches sexual maturity at an earlier age and smaller size than other locations (Hartnoll 1988b). There are several possible reasons for these observations: 1) The populations may be crowded on the island due to habitat encroachment from development, increasing competition for a limited food supply, thus, limiting body size. Cannibalism was frequently observed during the nightly road surveys and this behavior is often indicative of crowded conditions, presence of vulnerable individuals, and a stressed population (Lovrich & Sainte-Marie 1997). 2) Additionally, the smaller crab sizes could be due to genetic or environmental differences from Cayman in relation to other Caribbean regions studied in Britton et al. (1982). 3) Lastly, heavy human exploitation levels may have influenced the skewed size distribution (Hartnoll et al. 2006). Crabbers tend to favor the larger individuals because they provide the most meat and monetary value (pers. observ.). These larger crabs are often bolder and more conspicuous, increasing their likelihood of capture (Hartnoll et al. 2006). A single reason or a combination of these factors may have resulted in observations of smaller-sized *G. ruricola* on Grand Cayman.

Many decapods show asymmetry in the size and shape of their chelae, a phenomenon known as heterochely, which is often associated with fighting, signaling, and attracting mates (Hartnoll 1982). The major chela is not only larger than the minor chela, but it has a higher rate of relative growth so the difference becomes exaggerated with increased body size. Extreme heterochely is usually limited to males and is far less marked in females (Hartnoll 1988b) which is supported from this study's results.

Small *G. ruricola* (<10mm CW) individuals were mainly observed crossing Queen's Highway during June 2017 and were hardly seen foraging along the road edge in the forested areas. A similar observation was seen in Britton et al. (1982) where small-sized individuals (<40mm CW) were observed and collected from under stones or within cobble walls near the sea. This suggests *G. ruricola* activity patterns and habitat preferences are determined by age.

The vegetation on East End can be described as a dry, woodland/thicket mosaic composed of a low, open and/or dense canopy with thick undergrowth. The canopy height is between six to 12m and the trees have slender stems (15 to 20cm diameter at breast height) (Brunt 1994). Grand Cayman is a low-lying island (<18m in elevation) formed by two distinct formations of calcareous rock: the older limestone, called "bluff limestone", and a coastal limestone terrace termed "ironshore." Queen's Highway roadsides are dominated by these sparsely vegetated rock formations in the form of bedrock, loose carbonate cobble, horizontal sheets of eroded rock, and large pieces of dolomite (Jones 1994). *Gecarcinus ruricola* on Grand Cayman creates burrows out of these rock formations, most in the form of loose bedrock, but were often seen sheltering under large boulders, tree roots, or leaf litter. The distance from the sampling area off the highway edge is a steep drop in some areas, especially on the coastal roadside, providing numerous sheltered areas. On Cayman Brac, *G. ruricola* seems to occur in highest densities on the upper ironshore platform, along the vertical face of the bluff which is shaded by a forest (Britton et al. 1982). This is a similar description to the observation of

G. ruricola's habitat on Grand Cayman, where individuals were seen in highest densities among rocky areas shaded by dry forests and woodlands.

Summary & Conclusion

Gecarcinus ruricola males reach a larger maximum size than females, for all measured morphometrics on Grand Cayman. This is most likely due to how each sex allocates their energy utilization, as females expend greater resources on reproduction, at the expense of growth (Hartnoll 1988a). Overall, both sexes of *G. ruricola* on Grand Cayman seem to be smaller in terms of body size than other populations in the Caribbean. Furthermore, carapace widths for two ovigerous females from this study were documented to be considerably less than what has been considered as sexually mature in literature. The habitat preference for *G. ruricola* on Grand Cayman includes dry forests and woodlands growing among calcareous rock formations. Future studies would benefit from utilizing other crab sampling methods such as baited traps within burrows/retreats, as this study only focused on surface sampling, to obtain a more extensive overview of the age structure. Additionally, a similar study would be useful on Little Cayman and Cayman Brac, as these islands are less developed than Grand Cayman.

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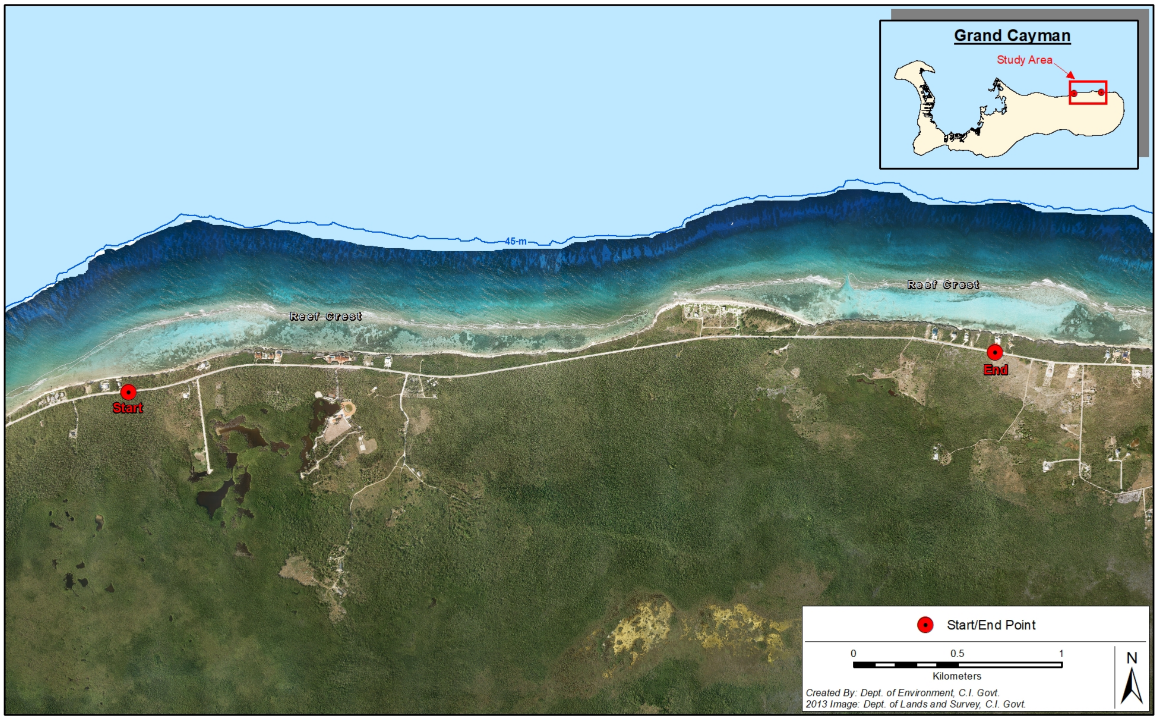

Figure 1. Map displaying the 4km study area on/along Queen's Highway, East End, Grand Cayman. Start point is section number one (0-100m) at the Queen's Monument and end mark is section number 40 (3900-4000m). Map created by the Department of Environment, Cayman Islands Government, March 2018.

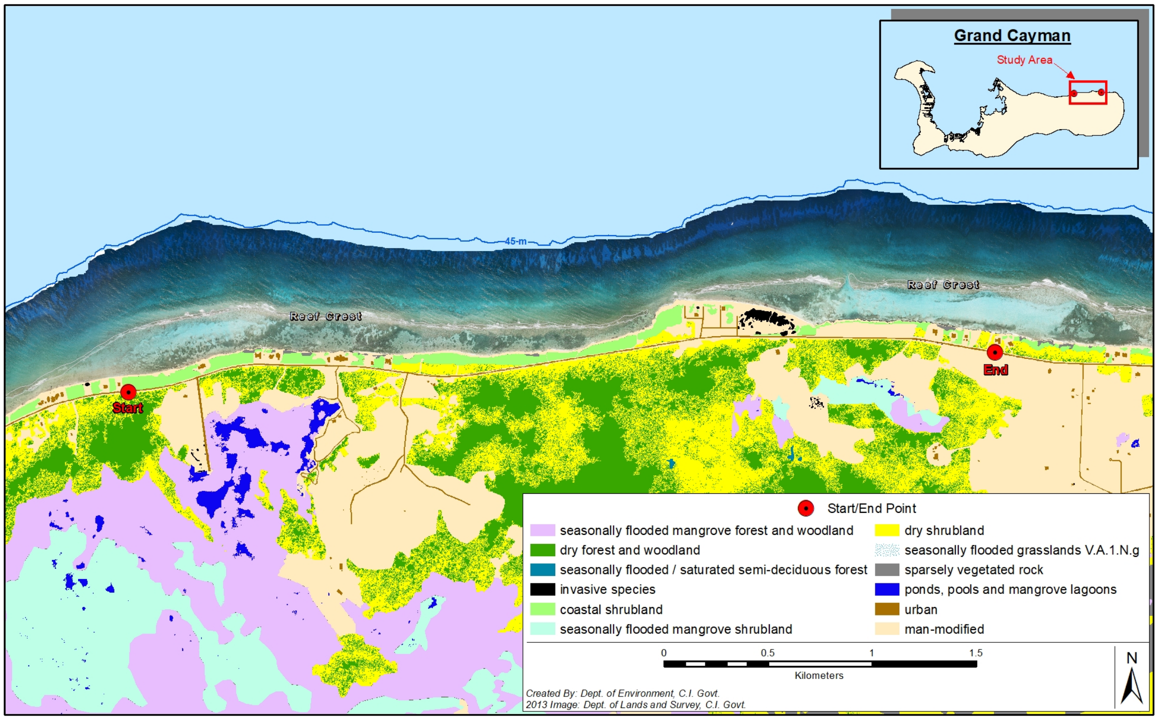

Figure 2. Map displaying the 4km study area on/along Queen's Highway, Grand Cayman illustrating land use/land cover classifications. Start point is section number one (0-100m) at the Queen's Monument and end mark is section number 40 (3900-4000m). Map created by the Department of Environment, Cayman Islands Government, March 2018.

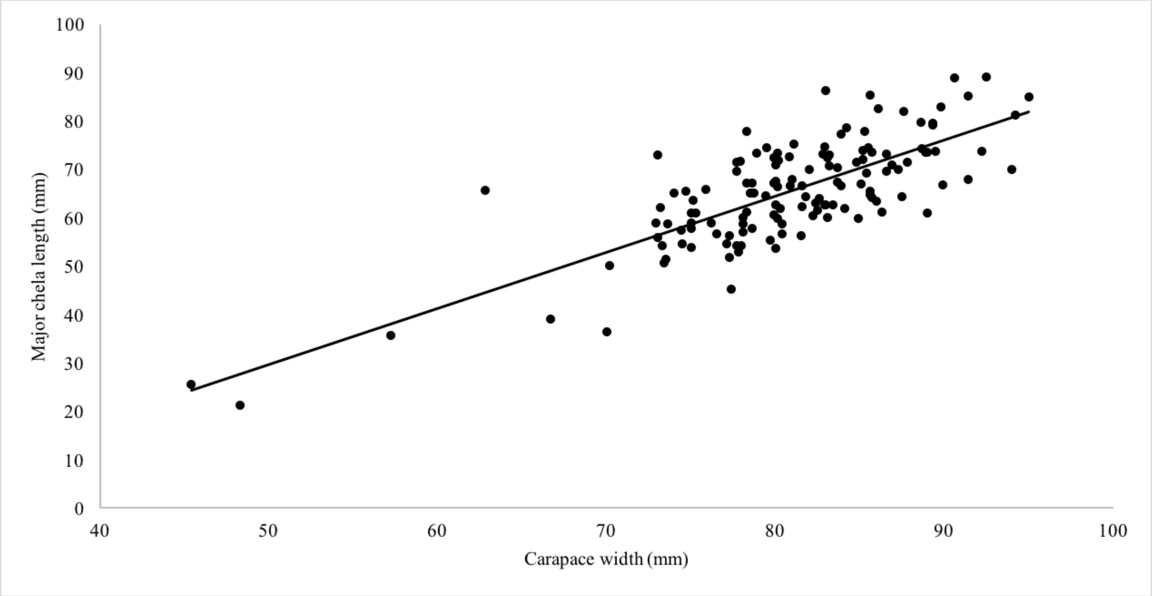

Figure 3. Carapace width (mm) versus major chela length (mm) for *G. ruricola* males captured from May to August in 2016 along Queen's Highway (n=186). Right-handedness was observed in 46.2% of individuals and left-handedness was noted in 41.3% (12.5% did not display heterochely). The trendline describes the pattern of the two variables. Note x-axis begins at 40.0mm CW.

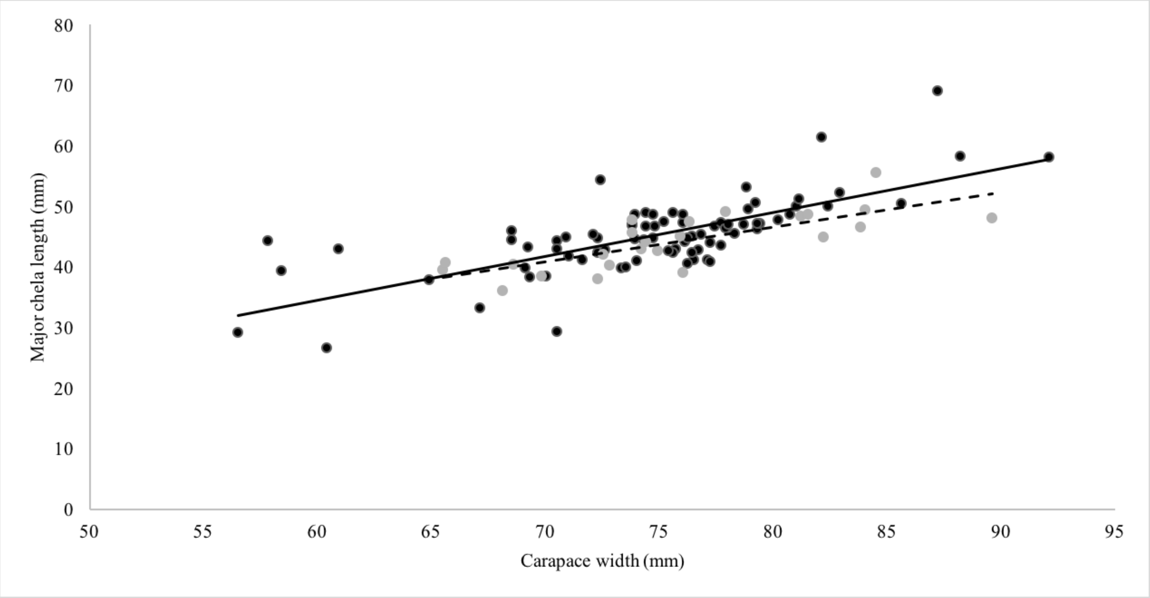

Figure 4. Carapace width (mm) versus major chela length (mm) for *G. ruricola* non-ovigerous females (black dots, solid line) and ovigerous females (grey dots, dashed line) captured from May to August in 2016 along Queen's Highway. In non-ovigerous females, right-handedness was observed in 20.2% of individuals and left-handedness was noted in 22.7% (57.1% did not display heterochely) (n=79). In ovigerous females, right-handedness was observed in 33.3% of individuals and left-handedness was noted in 16.7% (50.0% did not display heterochely) (n=24). The trendlines describe patterns of the two variables. Note x-axis begins at 50.0mm.

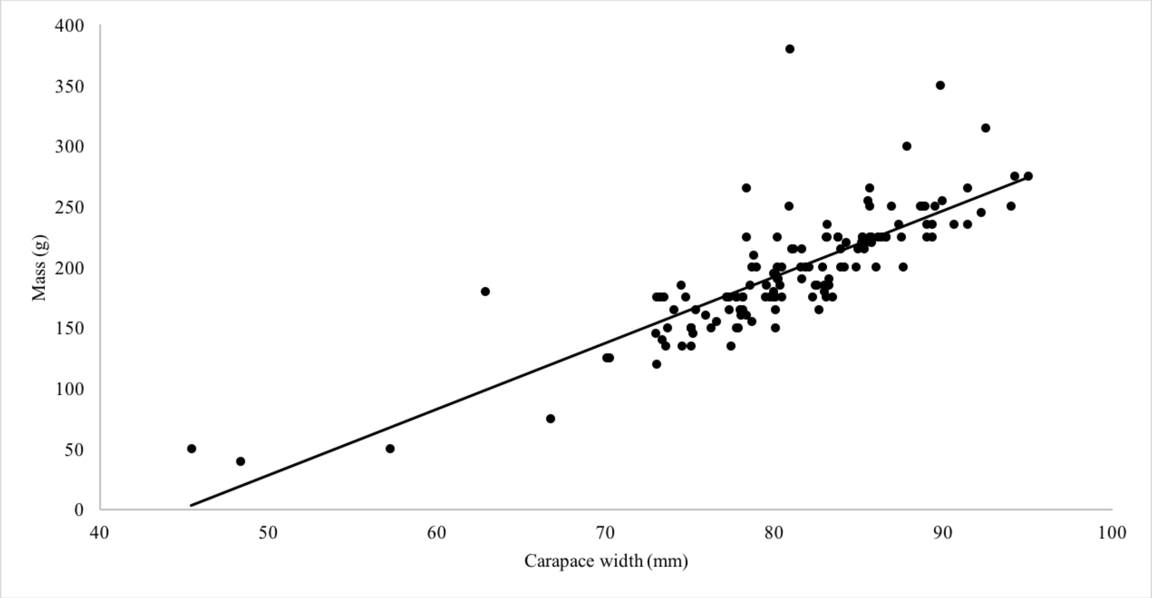

Figure 5. Carapace width (mm) versus mass (g) for *G. ruricola* males captured from May to August in 2016 along Queen's Highway (n=186). The trendline describes the pattern of the two variables. Note x-axis begins at 40.0mm.

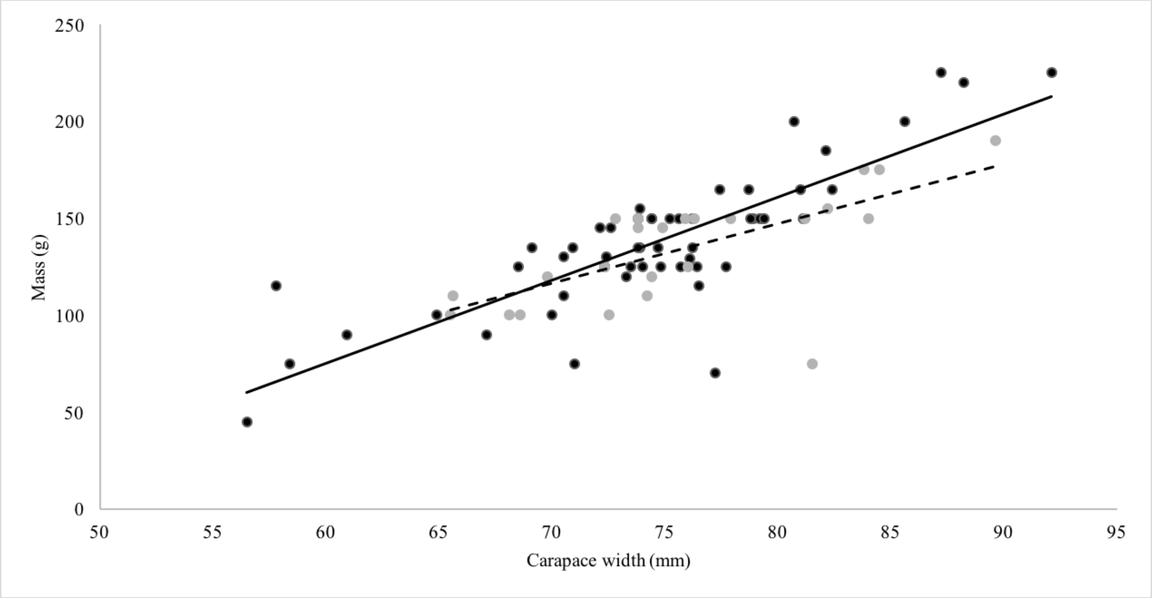

Figure 6. Carapace width (mm) versus mass (g) for *G. ruricola* non-ovigerous females (black dots, solid line) and ovigerous females (grey dots, dashed line) captured from May to August in 2016 along Queen's Highway (non-ovigerous n=79, ovigerous n=24). The trendlines describe patterns of the two variables. Note x-axis begins at 50.0mm.

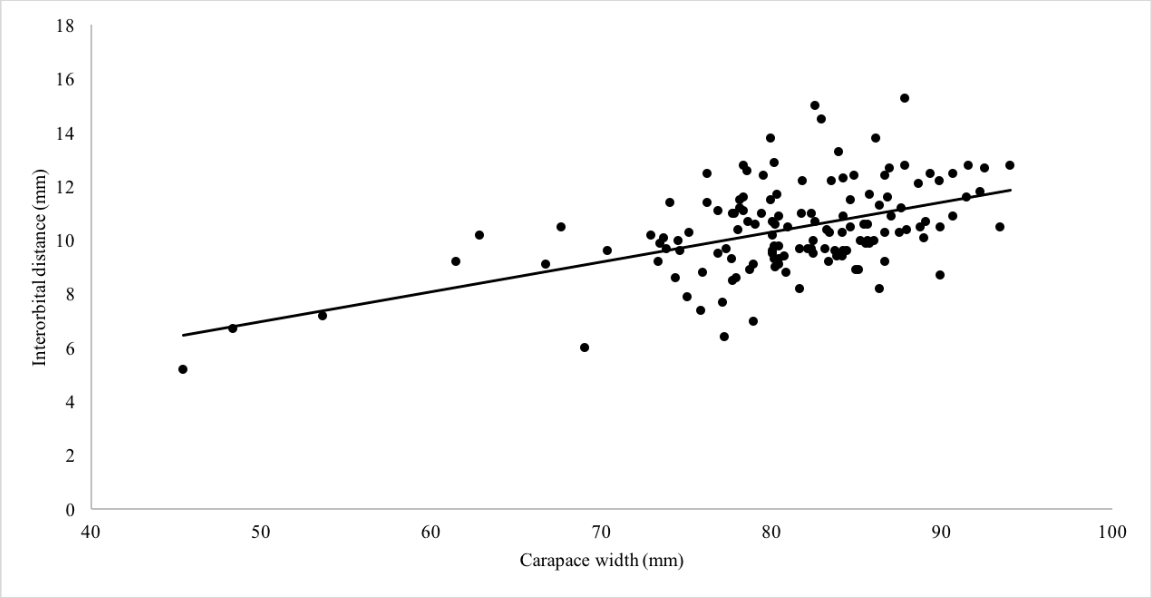

Figure 7. Carapace width (mm) versus interorbital distance (mm) for *G. ruricola* males captured from May to August in 2016 along Queen's Highway (n=186). The trendline describes the pattern of the two variables. Note x-axis begins at 40.0mm.

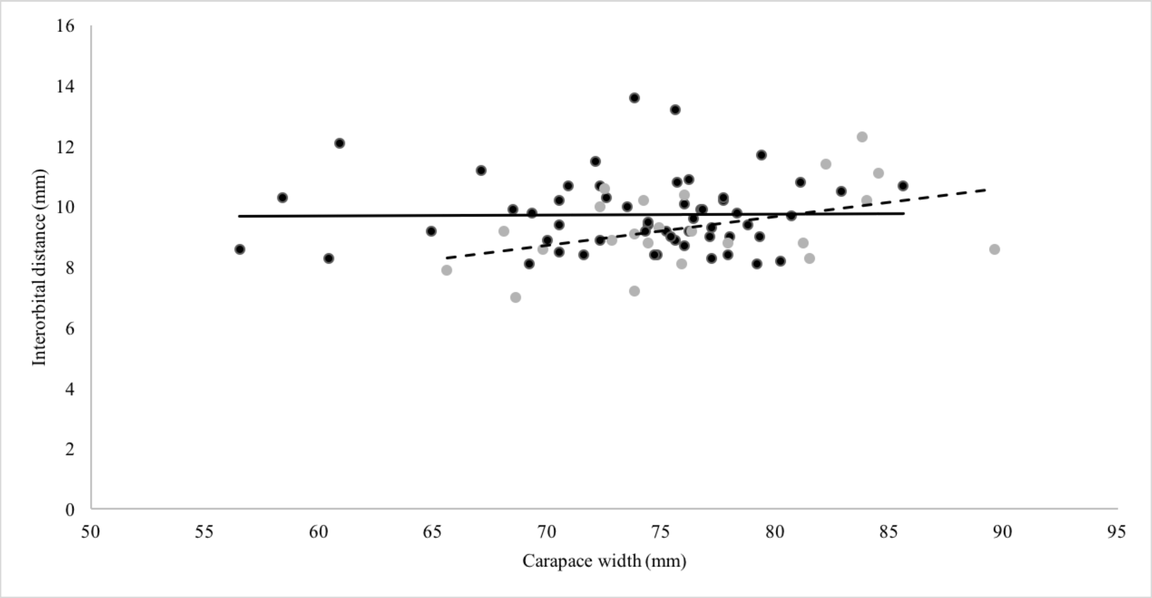

Figure 8. Carapace width (mm) versus interorbital distance (mm) for *G. ruricola* non-ovigerous females (black dots, solid line) and ovigerous females (grey dots, dashed line) captured from May to August in 2016 along Queen's Highway (non-ovigerous n=79, ovigerous n=24). The trendlines describe patterns of the two variables. Note x-axis begins at 50.0mm.

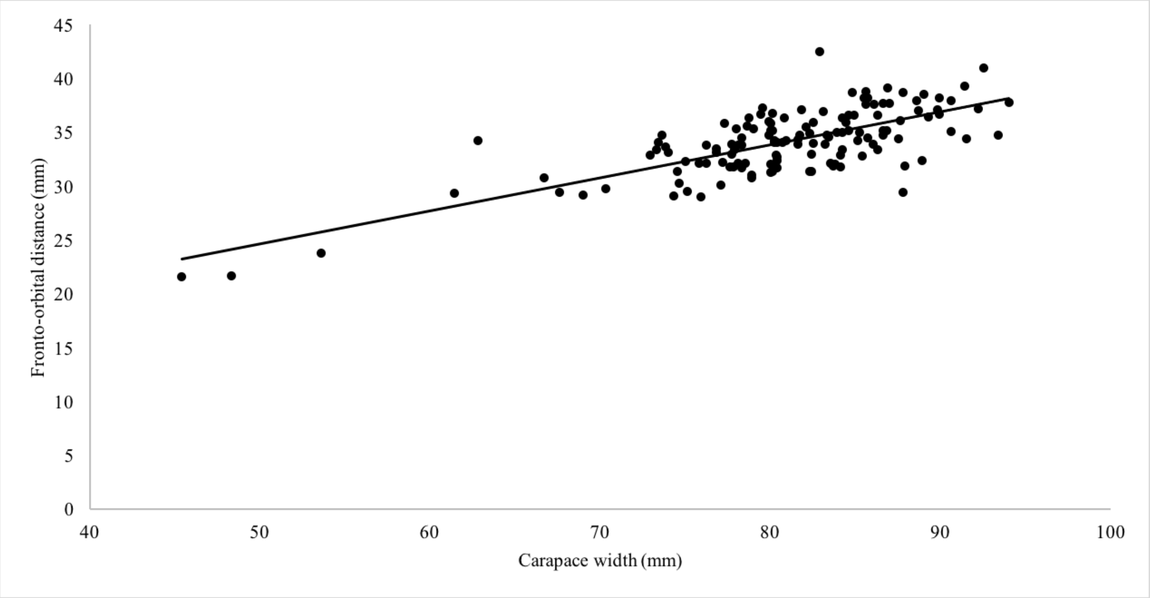

Figure 9. Carapace width (mm) versus fronto-orbital distance (mm) for *G. ruricola* males captured from May to August in 2016 along Queen's Highway (n=186). The trendline describes the pattern of the two variables. Note x-axis begins at 40.0mm.

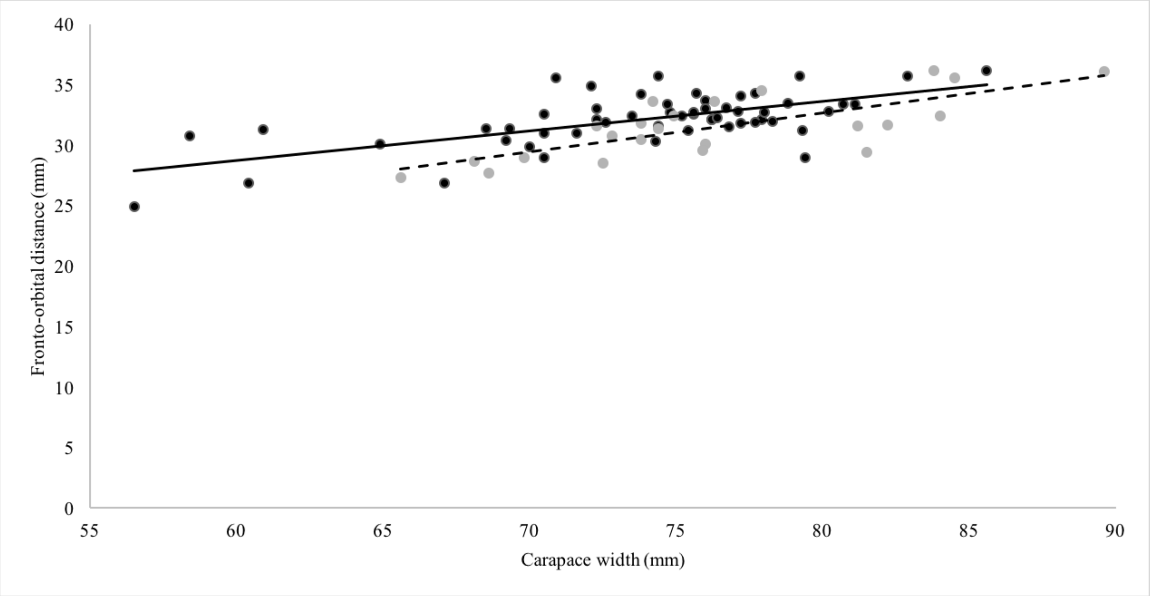

Figure 10. Carapace width (mm) versus fronto-orbital distance (mm) for *G. ruricola* non-ovigerous females (black dots, solid line) and ovigerous females (grey dots, dashed line) captured from May to August in 2016 along Queen's Highway (non-ovigerous n=79, ovigerous n=24). The trendlines describe patterns of the two variables. Note x-axis begins at 55.0mm.

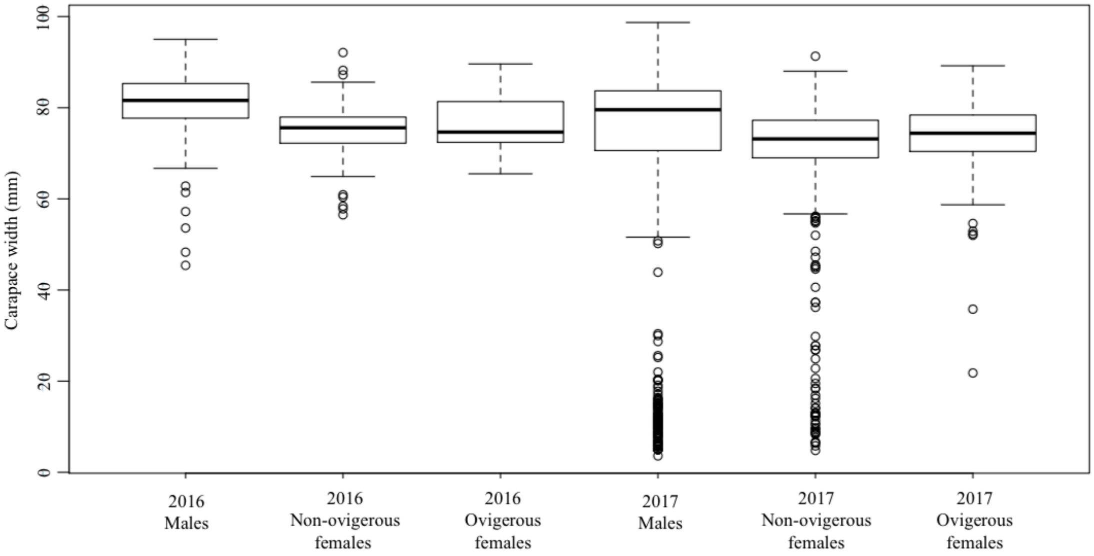

Figure 11. Carapace width (mm) ranges for *G. ruricola* males, non-ovigerous females, and ovigerous females from May to August in 2016 and 2017 along Queen's Highway, East End, Grand Cayman. Samples sizes are as follows: 2016 Males n=186; 2016 Non-ovigerous females n=79; 2016 Ovigerous females n=24; 2017 Males n=637; 2017 Non-ovigerous females n=560; 2017 Ovigerous females n=493.

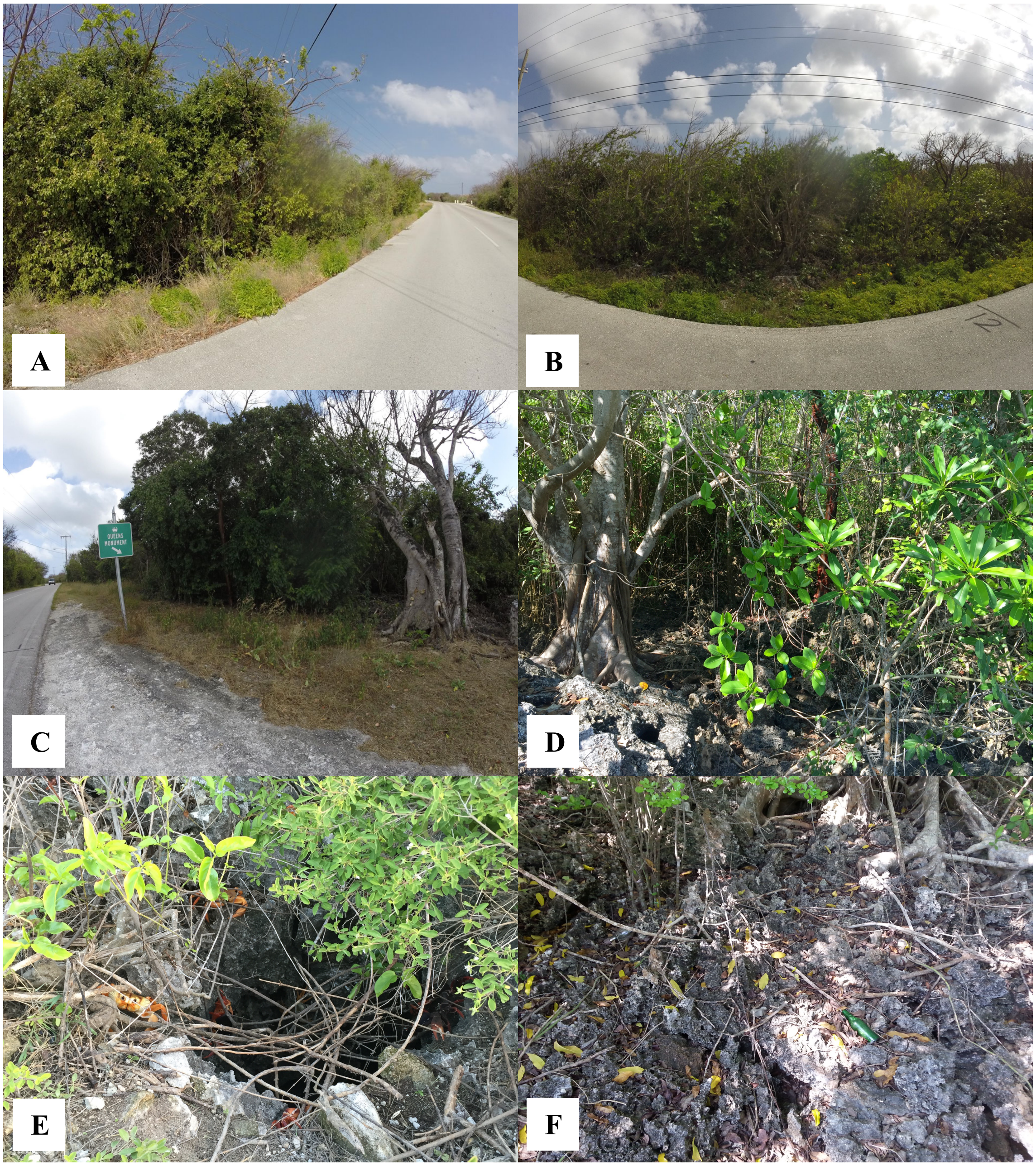

Figure 12. Photos from the study area on/along Queen's Highway, East End, Grand Cayman. A) Coastal roadside view; B) Inland roadside view; C) Queen's Monument denotes the beginning of the study area; D-F) Dry woodlands and forests with rocky ironshore substrates is the dominant habitat for *G. ruricola* on the island.

Table 1. Morphometrics obtained for *G. ruricola* from May to August in 2016 along Queen's Highway, East End, Grand Cayman (n=289). The value in parentheses in column *n* is associated with the sample size for the characteristics marked with an *. For each morphometric measured, the median is displayed above the range of values noted as (min-max).

n	Mass (g)	Carapace length (mm)*	Major chela length (mm)	Interorbital distance (mm)*	Fronto-orbital distance (mm)*
			Males		
186 (136)	195 (40-400)	61.8 (36.1-74.6)	66.2 (21.2-89.2)	10.3 (5.2-15.3)	34.2 (21.6-42.5)
			Non-ovigerous females		
79 (55)	145 (45-225)	56.8 (43.9-65.7)	44.9 (26.6-69.1)	9.5 (8.1-13.6)	32.3 (24.9-36.2)
			Ovigerous females		
24 (23)	145 (75-190)	58.3 (49.7-70.6)	44.5 (36.0-55.6)	9.1 (7.0-12.3)	31.6 (27.3-36.2)

Table 2. Descriptive statistics of *G. ruricola* carapace width (mm) by size and sex measured on/along Queen's Highway from May to August in 2016 (n=289) and 2017 (n=1761). Both sexes have been shown to reach sexual maturity at 50mm CW (Hartnoll et al. 2007), although two females <50 mm had eggs in this study. (S.E.=standard error)

Year	*n*	%<50 mm	Median	Min	Max	S.E.
Males						
2016	186	0.01 (2)	81.6	45.4	95.0	0.5
2017	637	11.9 (76)	80.1	10.5	98.7	0.8
Non-ovigerous females						
2016	79	0	75.6	56.5	92.1	0.7
2017	560	0.06 (36)	73.3	10.6	91.3	0.5
Ovigerous females						
2016	24	0	74.6	65.5	89.6	1.2
2017	493	0.004 (2)	74.4	21.8	89.2	0.3
Individuals <10mm						
2016	0	--	--	--	--	--
2017	71	0	6.8	3.6	9.0	0.2

** The %<50mm column represents the percentage of individuals that are less than what has been considered as sexually mature by Hartnoll et al. 2007 (>50mm CW). The value in parentheses is the number of individuals <50mm CW in the present study.*

Table 3. Dominant flora within the coastal and inland roadsides (500m^2) from May to August in 2017 along Queen's Highway, East End, Grand Cayman.

Scientific Name	**Common Name**
Bidens alba	Spanish needle
Bursera simaruba	Red birch
Capparis cynophallophora	Jamaican caper, Headache bush
Casuarina equisetifolia	Weeping willow
Catharanthus roseus	Periwinkle
Clusia flava	Balsam
Coccoloba uvifera	Seagrape
Coccothrinax proctorii	Silver thatch palm
Cocos nucifera	Coconut
Cordia gerascanthus	Spanish elm
Cynophalla flexuosa	Bloody head-raw bones
Dactyloctenium aegyptium	Egyptian crowfoot grass
Delonix regia	Flame tree, Royal poinciana
Ficus aurea	Golden fig
Lantana involucrata	Buttonsage
Leucaena leucocephala	Wild tamarind
Melinis repens	Natal grass
Morinda citrifolia	Noni fruit tree
Plumeria obtusa	Wild jasmine
Psidium guajava	Guava
Scaevola sericea	Beach naupaka
Stachytarpheta jamaicensis	Vervine
Tecoma stans	Yellow elder, shamrock
Tephrosia cinerea	Ashen hoary-pea

COASTAL MIGRATION OF THE BLACK LAND CRAB (*GECARCINUS RURICOLA*) ON GRAND CAYMAN ISLAND

Kinsey Tedford

Department of Biology, University of Central Oklahoma, Edmond, OK, 73034

ABSTRACT

Gecarcinus ruricola (black land crab) is found throughout Grand Cayman, and concern has been expressed from Cayman government officials regarding their possible declining populations and current distributions. Goals of this study were to determine activity levels for *G. ruricola* during the reproductive season, identify locations with the highest *G. ruricola* numbers, describe the distribution of the *G. ruricola* migrating population, note mass migrations of ovigerous *G. ruricola*, estimate *G. ruricola* mortality rates caused by vehicles, and discuss *G. ruricola* activity levels in relation to rainfall and the lunar cycle. Surveys were conducted in summer 2017 along a main highway in East End, Grand Cayman. Overall, high numbers of *G. ruricola* individuals occurred on the inland roadside in late May and June, and this shifted to the coastal side mid-July through August. Non-hierarchical cluster analysis confirmed two main clusters in each sex on the road. Generally, the middle region of the study area exhibited the greatest numbers of migrating crabs. The clustering of crabs along the highway most likely reflects habitat changes due to an increase in housing development. Ovigerous females displayed randomness in their occurrences throughout the summer with a higher prevalence of occurrence during nights of high crab activity. The two nights with the greatest overall road activity most likely coincided with spawning events. The migration season extends over three months, but intensity varies with time. The temporal pattern of roadkills generally reflected the migration strength. Moon illumination had a significant effect on *G. ruricola* activity levels, with increased road activity around the waning crescent moon phase. Rainfall amount showed a significantly positive correlation with the number of male and non-ovigerous females on the road. Knowledge gained from this study will provide Cayman government officials with baseline information and methods they can use to monitor Cayman's land crab populations in the future. This is the first comprehensive study of *G. ruricola* on Grand Cayman and it will provide a greater overall understanding of land crabs and their reproductive migration.

Keywords: Cayman Islands, Gecarcinidae, land crab, migration

INTRODUCTION

Land crabs comprise the family Gecarcinidae and include six genera: *Cardisoma*, *Discoplax*, *Epigrapsus*, *Gecarcinus*, *Gecarcoidea*, and *Johngarthia* (Chace & Hobbs, 1969; Türkay, 1970; Hartnoll, 1988; Perger *et al*., 2011). All members of this family follow a similar life cycle where a majority of the adult stage is terrestrial, though water reliance varies among species. All gecarcinid eggs must be hatched in the sea, where the larvae undergo planktonic development (Hartnoll, 1988). Land crabs occur on many islands throughout the tropics, where they are found in greatest numbers on low-lying terrain with densities often exceeding 1 crab/m^2 (Hartnoll, 1988; Green, 1997). There are three gecarcinid species documented in the Caribbean Islands: *Cardisoma guanhumi*

(Latreille 1852), *Gecarcinus lateralis* (Fréminville 1835), and *Gecarcinus ruricola* (Linnaeus 1758) (Hartnoll *et al.,* 2006; Baine *et al*., 2007).

Gecarcinus is the most terrestrial of the gecarcinids in the Caribbean and may occur at great distances inland and high altitudes. This genus is most often found in dry and shaded forested areas where it can burrow in soil, but more often shelters around rocky areas (Bliss *et al*., 1978; Britton *et al*., 1982; Hartnoll *et al*., 2006; Hartnoll & Clark, 2006). *Gecarcinus* obtains water from food, by drinking dew, or through osmotic uptake from damp substrates to avoid frequent water immersion (Wolcott & Wolcott, 1984).

Cardisoma guanhumi and *G. ruricola* are mainly nocturnal, except during the reproductive season when large numbers may become active during the day. Nocturnal activity in *G. ruricola* is stimulated by rainfall, but often repressed during nights of bright moonlight that is suspected to disorient them (Gifford, 1962; Hounsome, 1994; Hartnoll *et al*., 2006). *Gecarcinus lateralis* is primarily diurnal, although activity patterns vary based on locality (Bliss *et al*., 1978).

The gecarcinid reproductive cycle is closely associated with cues received from environmental factors, such as resource availability, temperature, lunar phases, rainfall, tidal cycles, and competition between species (Adiyodi, 1988; Adamczewska & Morris, 2001). Baine *et al.,* (2007) found that peak migrations in *G. ruricola* correlated with lunar phases, but were more strongly influenced by rainfall. In *Cardisoma hirtipes*, spawns occurred three or four days before full moons in the Soloman Islands, while in *G. lateralis*, spawning occurred four or five nights following full moons during the breeding season in Bermuda (Wolcott & Wolcott, 1982; Foale, 1999). The spawning date of

Gecarcoidea natalis was fixed by lunar phases on Christmas Island, but a "rushed" migration during that specific year occurred due to late seasonal rains prompting crabs to walk directly to their shoreline destinations (Adamczewska & Morris, 2001). Spawning migrations are common in gecarcinids that move down to the sea for egg release and several spawns per year may occur, depending on the start of seasonal rains and geographic location (Baine *et al*., 2007). Mass migration occurrences have been documented in *Cardisoma*, *Gecarcinus*, *Gecarcoidea*, and *Johngarthia* (Gifford, 1962; Johnson, 1965; Bliss *et al*., 1978; Adamczewska & Morris, 2001; Hartnoll & Clark, 2006; Hartnoll *et al*., 2009).

Within the Cayman Islands, *G. ruricola* occurs on all three islands (Hounsome, 1994, Cayman Department of Environment, personal communication). This species is most commonly found among calcareous limestone formations and dry woodlands seeking refuge around rocky ironshore crevices and tree roots (Chace & Hobbs, 1969; Hounsome, 1994). *Gecarcinus ruricola* is an omnivore, feeding on leaf litter, fruits, carrion, and will occasionally show cannibalistic behaviors (Wolcott & Wolcott, 1984; Dunham & Gilchrist, 1988). Seasonal rains during May through August initiate migration and the reproductive season on Grand Cayman. *Cardisoma guanhumi* and *G. ruricola* are exploited for human consumption during that period on Grand Cayman, although *G. ruricola* seems to be consumed on a smaller scale.

The Cayman Department of Environment has expressed concern regarding possible declining *G. ruricola* populations and their current distributions. It has been suggested *G. ruricola* numbers are declining across the island due to a combination of increased vehicular traffic and light pollution, habitat loss, overexploitation from humans, and isolation from resources such as food, shelter, and potential mates (Cottam *et al*., 2009, Cayman Department of Environment, personal communication). The goals of this study were to determine activity levels for *G. ruricola* during the reproductive season, identify locations with the highest *G. ruricola* numbers, describe the distribution of the *G. ruricola* migrating population temporally and spatially, note mass migrations of ovigerous *G. ruricola*, estimate *G. ruricola* mortality rates caused by vehicles, and discuss *G. ruricola* activity levels in relation to rainfall and lunar cycle.

METHODS

Study area

Preliminary studies occurred in 2015 and 2016 during the reproductive season, which coincides with the rainy season, to determine the migration area locations. In addition to these observations and advice from the Cayman Department of Environment, the study area was selected to occur in East End, Grand Cayman. Specifically, on and alongside Queen’s Highway, a major two-lane highway between North Side and Colliers Beach. Queen’s Highway runs parallel to the coast, separating the crab’s inland habitat from the shoreline (Fig. 1-2, Chapter 3).

Grand Cayman has a mean annual temperature of 27.9°C and mean monthly precipitation of 118.96mm per year. However, during the rainy season (May to late October, Burton 1994), there are increases in the mean temperature (29.2°C) and mean precipitation during that time (174.5mm). Relative humidity levels range from 76 to 79% year-round (National Oceanic and Atmospheric Sciences, https://www7.ncdc.noaa.gov/CDO/cdoselect.cmd?datasetabbv=GSOD).

Reproductive migration

Surveys occurred from May through August 2017 for 12-weeks along the coastal road. Populations were surveyed to document *G. ruricola* activity within a 4km stretch of the road, six to seven days a week. Queen's Highway was divided into 40 (100m) sections, conveniently indicated by roadside distance markers (section one: 19° 21' 8.6 N, 81° 8' 16.5'' W, section 40: 19° 21' 10.4 N, 81° 7' 4.4'' W).

Land crab activity levels, also referred to as counts, were documented on and off the road. Direct counts of active *G. ruricola* were surveyed within the marked 100m sections to estimate activity levels along the road edge. The counts occurred along coastal and inland roadsides from four 500m^2 (5x100m) sections each night (n=256 samples). The statistical R program was used to generate random numbers prior to sampling to determine which roadside section to survey (v. 3.4.2; R Core Team, 2017). Generally, active crab counts began following sunset between 2000 and 2100 hours and were completed in <80 minutes (20 minutes/roadside section). Preliminary studies in 2015 and 2016 indicated activity at this time was typical of migration intensity. As stated by Green (1997), a crab was considered active if it was more than half-way out of the burrow mouth. Because *G. ruricola* occurs almost exclusively under a forest canopy, any type of rocky crevice, hole, or other shelter type (tree roots) was also included if the crab was seen more than half-way out of the retreat entrance (Britton *et al.*, 1982).

Additionally, *G. ruricola* activity was monitored directly on the road throughout the entire study area each night of sampling (n=64 samples). The survey protocol was to drive and/or walk (no faster than 20km/hr) along the coast road between 2100 and 2300. Crabs were sexed by abdominal shape (Adiyodi, 1988) and the presence of eggs on females was recorded each time an individual was encountered, as well as the location (section number 1-40) the individual occurred in was documented. It was not possible to estimate total numbers of *G. ruricola* migrating each night, only the number on the road during the survey. This method provides comparable data over time and between locations, on the relative numbers migrating during the reproductive season. The road is a constant width of 8.5m, so comparisons between locations are justifiable.

Land crab remains of previous roadkills were marked with black spray paint throughout the 40 road sections (850m^2) of the highway for the entire data collection. Four different road sections were marked during each sampling date (n=234 samples). During each sampling period, roadkills lacking a black mark were counted and the number of days since marking were noted. These numbers were used to estimate daily mortality rates caused by vehicular traffic between site visits. Because roadkills are often scavenged by animals (birds and/or feral cats/dogs) and washed away by rain, roadkills were also documented during the nightly road surveys (n=64 samples). This data was used to complement the live crab data to determine which road section(s) and collection date(s) exhibited the highest mortality.

Environmental factors

Moon illumination (%) values were obtained from U.S. Naval Observatory Washington, DC for each sampling date to relate to *G. ruricola* activity levels (U.S. Naval Observatory, http://www.usno.navy.mil/USNO). Daily rainfall amounts (mm) were obtained from the Cayman Water Authority rain gauge network to compare with crab activity levels. The rain gauge station was located within the sampling area near road section 31 (19° 21’ 12.7 N, 81° 7’ 37.2’’ W).

Statistical analyses

Land crab activity levels along the coastal and inland roadsides were transformed into continuous data by dividing the total number of active crabs (counts) by 500m^2. The data were then tested for normality using a Shapiro-Wilk test and equality of variances through a Levene test. Based on the results of those analyses, a Mann-Whitney U test was used to determine whether significant differences in *G. ruricola* activity levels existed between coastal and inland roadsides.

A runs test was used to determine if *G. ruricola* activity levels on the road were distributed randomly among the predetermined sections on the highway and throughout the collection dates during the reproductive season. A runs test is a non-parametric analysis that ranks the dataset and tests the hypothesis that elements of the sequence are mutually independent (Siegel & Castellan, 1988). Cluster analyses were then used to group high and low numbers of crab counts to specific road sections using *k*-means clustering. This non-hierarchical clustering technique separates the number of observations (n) into clusters (*k*) in which each observation belongs to the cluster with the closest mean, serving as a cluster prototype. It maximizes homogeneity within groups by splitting a set of objects into a selected number of groups by maximizing between-cluster variation relative to within-cluster variation (Legendre & Legendre, 1998; Vermeij & Bak, 2002). The silhouette method was then used to validate the optimum number of clusters (*k*) chosen during *k*-means clustering (Rousseeuw, 1987). Silhouette coefficients have a range of [-1, 1]. A coefficient near +1 indicates the sample is far away from the neighboring clusters, a value of 0 indicates the sample is on or close to the decision boundary between two neighboring clusters, and a negative value indicates that samples might have been assigned to the wrong cluster.

To determine if moonlight had an effect on the number of *G. ruricola* individuals on the road, a Shapiro-Wilk test was used to check for normality followed by a Kruskal-Wallis rank sum test. Because lunar phases are often arbitrary, categories were created to represent six of the eight lunar phase cycles using illumination ranges: New moon (0-1%), waxing crescent (2-49%), waxing gibbous (50-98%), full moon (99-100%), waning gibbous (50-98%), and waning crescent (2-49%). First quarter and third quarter were removed because none of the 2017 dates had exactly 50% of the moon fraction illuminated. A Spearman's rank-order correlation test was used to measure the strength and direction of association between rainfall (mm) amount and *G. ruricola* activity levels for each sex. A significance level of 0.05 was chosen for all statistical analyses and used the statistical program R (v. 3.4.2; R Core Team, 2017).

RESULTS

Analysis revealed there was a significant difference in *G. ruricola* activity levels between coastal and inland roadsides (Mann-Whitney U test, $U=6072.5$, $p<0.0001$). The highest density of crabs observed on the coastal roadside occurred on 24 July 2017 with a maximum number of 204 individuals within the $500m^2$ section, while the maximum number of individuals on the inland side was 217 on 23 June 2017 (Fig. 3). There was a total of 2,905 active crabs documented on the coastal roadside throughout the study, with an average of 31 individuals and a median of 15 individuals per 500m^2. There was a total of 2,486 crabs recorded along the inland roadside, averaging 19 individuals and a median of seven individuals per 500m^2 section.

High and low numbers of crabs were not scattered randomly on the highway (Runs test: males Z=-5.673, p<0.0001; ovigerous females Z=-5.178, p<0.0001; non-ovigerous females Z=-4.9064 p<0.0001; females Z=-5.673, p<0.0001). Section 12 on the highway contained the highest number of migrating males (46 individuals, 0.062%, n=736) and non-ovigerous females (49 individuals, 0.082%, n=597), while section 19 represented the area with the greatest number of ovigerous females (52 individuals, 0.105%, n=494) (Fig. 4).

Non-hierarchical (*k*-means) cluster analysis confirmed there were two main clusters observed in each sex among the predetermined road sections (Table 1, Fig. 5). The optimum value chosen (2) for *k* clusters was confirmed by the calculated average silhouette width (0.73). In addition, the silhouette coefficients for each of the two clusters were either above or near the average silhouette width (0.76, 0.66). Table 1 provides a detailed summary of cluster size, cluster mean, and road sections on Queen’s Highway associated with each cluster. The amount of variation due to clustering was relatively high for each sex (males: 90.3%; non-ovigerous females: 84.5%; ovigerous females: 85.8%). Overall, sections 11 to 24 exhibited the greatest numbers of migrating *G. ruricola* numbers along the highway. Males and non-ovigerous females were more prevalent at the beginning of this specific region, while ovigerous females were more often seen towards the end.

When analyzing *G. ruricola* activity levels and sampling date, individuals were not randomly scattered on the road throughout the 12-week collection period (Runs test: Z=-4.2936 p<0.0001). High and low numbers of migrating males and non-ovigerous females were not produced in a random manner, although ovigerous females exhibited randomness during the reproductive season days (Runs test: males Z=-3.9788, p<0.0001; non-ovigerous females Z=-2.202, p=0.02766; ovigerous females Z=0.29725, p=0.7663). Nights with the highest numbers of migrating crabs, specifically ovigerous females, occurred on 18 June and 16 to 17 July 2017 (Fig. 6).

An average of six *G. ruricola* individuals/850m^2 were estimated to be killed each night during the 12-week study. During the road surveys, sections 11 to 15 and 17 to 19 exhibited the highest number of roadkills (Fig. 7). There were at least 100 roadkills recorded each night along the 4km highway stretch from 18 to 20 June (total=573 roadkills), 23 to 24 June (total=500 roadkills), 16 to 18 July (total=1,212 roadkills), and 24 July 2017 (total=100 roadkills) during the road surveys.

Lunar phase category had a significant effect on the number of crabs for males (χ^2=20.719, df=5, p=0.0009), non-ovigerous females (χ^2=32.024, df=5, p<0.0001), and ovigerous females (χ^2=14.67, df=5, p=0.0118) during the road surveys (Fig. 8). Box and whisker plots demonstrate the distribution and variability for *G. ruricola* activity levels in relation to the lunar cycle (Fig. 9-11).

A positive correlation was observed between rainfall amount and *G. ruricola* activity levels for both sexes, although the results were only significant in males and non-ovigerous females (males: Spearman’s rho=0.4294, df=62, p=0.0004; non-ovigerous females: Spearman’s rho= 0.3390, df=62, p=0.0061; ovigerous females: Spearman’s rho=0.1792, df=62, p=0.1563) (Fig. 12). Based on Spearman's rank coefficient values, *G. ruricola* males showed a stronger positive relationship with rainfall than females.

DISCUSSION

High *G. ruricola* activity levels along the road occurred on the inland roadside in late May and June, and this shifted to the coastal side mid-July through August. There were two migration peaks observed in 2017 and it is likely that after the first migration around 18 June, the crabs remained on the coastal road edge until the next peak on 16 July. Land crabs spend a majority of time resting in crevices and burrows, with brief periods occurring when energy demands may increase due to behaviors such as a predator escape response, prey pursuit, or fight (Herreid & Full, 1988). Another possible reason for *G. ruricola* remaining on the coastline may have been to decrease the amount of energy expenditure from moving around to increase reproductive output (Childress, 1972; Bertness, 1981).

High numbers of *G. ruricola* males, non-ovigerous females, and ovigerous females all displayed distinct clusters along the middle region of the highway. There are at least three pathways within this region on the coastal roadside leading directly to the sea (Fig. 13). The pathways have sandy bottoms, lack vegetation, and most paths are shaded by overhanging trees surrounding woodland forests. Additionally, the distance from the road edge to the water within sections 20 to 22 is closer (distance <0.03km) than any other area on the highway (distances range from 0.03 to 0.2km elsewhere in the study region). A possible reason for high numbers of ovigerous females in these three sections may have been due to the shorter distance to reach the ocean either to spawn or dip their abdomens in the water to avoid desiccation. The distance an ovigerous female, particularly *C. guanhumi*, travels to the sea to spawn must occur within 48 hours of leaving their burrow or the egg mass will most likely disintegrate (Gifford, 1962). Females of *G. lateralis* must release their larvae within 10 hours of leaving their burrow for similar reasons to avoid desiccation from ambient heat (Klaassen, 1975; Bliss *et al.*, 1978). Klaassen (1975) concluded that such a narrow time span for larvae release prevents long spawning migrations to the sea (Gifford, 1962; Wolcott & Wolcott, 1982). The ovigerous *G. ruricola* individuals in this study were seen in large numbers on the road on 18 June (103 individuals) and over the course of two consecutive nights from 16 to 17 July (67-192 individuals/night). Because *G. ruricola* is more tolerant of dry conditions than the other two gecarcinid species mentioned, it may be possible the eggs are also tolerant of these conditions. This would allow an ovigerous *G. ruricola* to be exposed for a longer period of time.

The grouping of certain road sections between the two clusters likely relates to habitat changes, specifically the presence of development, within the study area on Queen's Highway (Fig. 13). The cluster results indicated low numbers of individuals for both sexes in at least one of the two clusters. Generally, the first cluster corresponds with developed areas and low crab densities (males=$3.9\text{x}10^{-4}$ individuals/m^2, non-ovigerous females=$2.6\text{x}10^{-4}$ individuals/m^2, ovigerous females=$1.3\text{x}10^{-4}$ individuals/m^2); while the road sections comprising the second cluster lack surrounding development, resulting in higher crab densities (males=$3.4\text{x}10^{-3}$ individuals/m^2, non-ovigerous females=$3.5\text{x}10^{-3}$ individuals/m^2, ovigerous females=$2.5\text{x}10^{-3}$ individuals/m^2). One major difference in the low number cluster is *G. ruricola* individuals are more aggregated at the beginning of the highway as compared to the end. Development (e.g., housing or fence lines) along the coastal edge exists among sections one to 12 and 27 to 40, with a greater amount of man-made structures at the beginning of the road. The middle region of the sampling area, consisting of sections 13 to 26, lacks coastal side development. The loss of a forested habitat is a considerable issue on the island as tourist-related development and urbanization continues. Furthermore, habitat loss along the coastal side is a particular threat because it hinders the seaward migration of ovigerous females to release larvae, as well as re-emerging megalops during the migration inland (Baine *et al*., 2007). It is crucial that suitable terrestrial habitats remain because *Gecarcinus* megalops migrates inland into coastal forests (distance of >0.1km) before molting to the first crab instar. This is unique to other gecarcinid species where the molt to the first instar occurs in the water, or in moist adjacent habitats (Hartnoll & Clark, 2006; Hartnoll *et al*., 2014).

Gecarcinus ruricola males and non-ovigerous females on the road displayed no random pattern in occurrences throughout the days of the reproductive season, although ovigerous females were more prevalent during nights of high crab activity. The three nights (18 June, 16 July, 17 July 2017) with the greatest overall activity most likely coincided with spawning, although data are not available on the migration patterns or crab activity levels at the shoreline. The precise timing of female spawning behavior may differ from their migration patterns across the road. In San Andrés, the migration of *G. ruricola* females with ripe eggs were greater at the period around the new moon, suggesting that larval release may be concentrated at such periods (Hartnoll *et al*., 2007; Hartnoll *et al*., 2010). A similar observation was seen to be true on Grand Cayman in *G. ruricola*. Analysis revealed there was a significant effect on crab activity and moonlight.

Crab activity was highest when the moon illumination was between 2-49% (waning crescent). According to the U.S. Naval Observatory, the new moons were respectively around 24 June and 24 July 2017 and the high crab activity peaks documented in *G. ruricola* on Grand Cayman were less than a week before these dates. Ovigerous females were most likely in route to the sea during this timeframe before the new moon phase.

One study suggests *G. ruricola* females produce one clutch of eggs per year and make a single annual migration to the sea, making it unlikely females could lay more than once in a reproductive season (Baine *et al*., 2007; Hartnoll *et al*., 2007). Females do not necessarily need to mate each time before laying because unused sperm can be stored for later use, although fertilization rates may decline with time. Furthermore, the stored sperm may be lost as the female molts (Hartnoll *et al*., 2007). A high number of non-ovigerous *G. ruricola* females were more abundant on days following the new moon on 18 July (103 individuals), although no data exists on if these were recently spawned individuals. There was also an unusually large number of active *G. ruricola* males (90-125 individuals/night) on the road from 18 to 20 June. Because movement is costly in terms of energy expenditure, it is possible that males invested a large amount of energy at the beginning of the reproductive season in June to increase their opportunity of intercepting a female to mate. The males may have been concentrating their peak activity levels around the new moon when there was a large number of *G. ruricola* females on and alongside the highway.

Large males are competitively superior and dominate the earlier mating opportunities during migration. This results in smaller males migrating further distances to improve their chances to mate (Hartnoll *et al*., 2007). The high number of males migrating across the road on Grand Cayman were on the smaller end of the carapace width range scale (mean CW=72.7mm, median CW=80.1mm, n=637, Chapter 3), as *G. ruricola* males may reach a maximum carapace width of 109.4mm (Britton *et al*., 1982). The larger males on Grand Cayman may have already mated in the inland forested areas earlier in the reproductive season, which resulted in the observations of smaller males sampled on the road. The males from this study most likely remained on the coastal side of the highway for the remainder of the data collection to increase their chances of courting a female. In addition, there is a general trend in gecarcinids for the migration period to coincide with the rainy season, most likely lowering desiccation stress (Adiyodi, 1988; Hartnoll *et al*., 2007). Heavy rainfall (243.2mm) from 15 to 20 June 2017 most likely stimulated crab activity the following days, especially in males. Overall, migration patterns in males are determined by mating opportunities provided by female receptivity at different stages of their migration, and activity is further enhanced by rainfall (Hartnoll *et al*., 2007).

The *G. ruricola* migration season on Grand Cayman extends over three months, but intensity varies with time. Migrating *G. ruricola* females must cross the road both on their way to the sea and on their return after larval release. On both occasions, they are at risk from vehicular traffic and many are killed. Roadkill is also a risk for the juvenile crabs (megalops) when they migrate from the sea to the forested areas (Baine *et al*., 2007). Roadkill data and the temporal pattern of roadkills along Queen’s Highway generally reflected migration intensity. The number of roadkills documented on the road following the July mass migration was much higher than June. Sampling time remained consistent throughout the entire data collection, but other factors such as traffic flow, cloud cover, rainfall amount, humidity levels, or human exploitation, may have influenced the number of migrating crabs sampled during the surveys.

Future management recommendations

Based on the locations with the highest *G. ruricola* activity and roadkill numbers, it may be useful for the Cayman Department of Environment to purchase land for protection surrounding those areas, especially along the coast. Road traffic is an increasing source of mortality for land crabs on Grand Cayman, especially when they are most active, at night, after rain, or during migration. Installation of crab warning signs in the road sections on Queen's Highway with the highest activity levels would alert drivers to the presence of land crabs as an attempt to reduce vehicular caused mortality. Flashing lights on those signs during nights with high *G. ruricola* activity, as noted from this study during the two migration peak timeframes, would also draw attention to crabs crossing the highway. Land crabs use a combination of mechanisms to orient themselves to their spawning destinations such as polarized light, moon brightness, prevailing winds, as well as olfactory and magnetic cues (Wolcott & Wolcott, 1982). In this study, both sexes of *G. ruricola* are migrating several nights before a new moon, when the presence of natural light is decreasing and artificial street light remains constant. This is a critical time of the year for ovigerous females, as they may be attracted and/or sensitive to artificial light (Longcore & Rich, 2004). It would be beneficial to remove or dim street lights in the high crab activity areas within the road sections to deter the number of wandering crabs off the road and instead direct them to the sea. If removing street lights was a safety concern, adjusting the spectral composition of white light (e.g., switching from ultraviolet/blue light to red light bulbs) in specific street lights may decrease the number of crabs on the road in the highly crab trafficked areas. Arthropods are not all equally attracted to the same light color temperature, so it would be useful to experiment with various degrees of light to predict attractiveness (Longcore *et al*., 2015; Swaddle *et al*., 2015). Land crabs are exploited for food on Grand Cayman during the reproductive season, but total catch figures are unknown. It may be necessary to implement licensing fees, limit collecting times, or establish bag limits following the obtainment of a more accurate picture of catchery numbers. Lastly, public outreach through televised news reports, newspaper/internet articles (such as the bimonthly reports in the Cayman Department of Environment's newsletter, *Flicker*), and through pamphlets highlighting a summary of this study would all bring awareness for land crab populations and their protection on Grand Cayman.

Summary & Conclusions

As the first comprehensive study *of G. ruricola* on Grand Cayman, this study provides information on their activity patterns throughout the reproductive season in 2017. The migration season extends over three months on Grand Cayman, but intensity varies with time. High roadside activity levels shifted from inland to the coastal edge following the first migration peak in June. By remaining on the coastal roadside, crabs were more likely to conserve energy and increase reproductive output. There were two mass migrations observed during this study with each resulting in high numbers of crabs crossing the road and high roadkill numbers. *Gecarcinus ruricola* individuals were not randomly scattered along the highway; instead each sex showed a distinct clustering distribution which most likely resulted due to habitat changes from development. During the reproductive season nights, ovigerous females exhibited randomness in their prevalence and those random nights of activity most likely coincided with spawning events. The number of roadkills generally reflected the migration intensity. Moonlight had a significant effect on the number of *G. ruricola* individuals on the road and rainfall enhanced overall activity on Grand Cayman.

Future studies should aim to estimate the population density of *G. ruricola* during the reproductive and non-reproductive seasons in order to characterize specific habitat requirements and enable population size estimation on Grand Cayman. It is essential to develop robust population numbers to adequately assess population numbers in the future. It would be beneficial to utilize tracking devices to map the movements and migration routes of *G. ruricola* (both on the road and along the shoreline) in order to identify potentially important migratory corridors along Queen's Highway. An extensive time-series analysis of moon illumination, sky conditions, humidity, and rainfall would be valuable to predict mass migrations of *G. ruricola* on Grand Cayman in the future.

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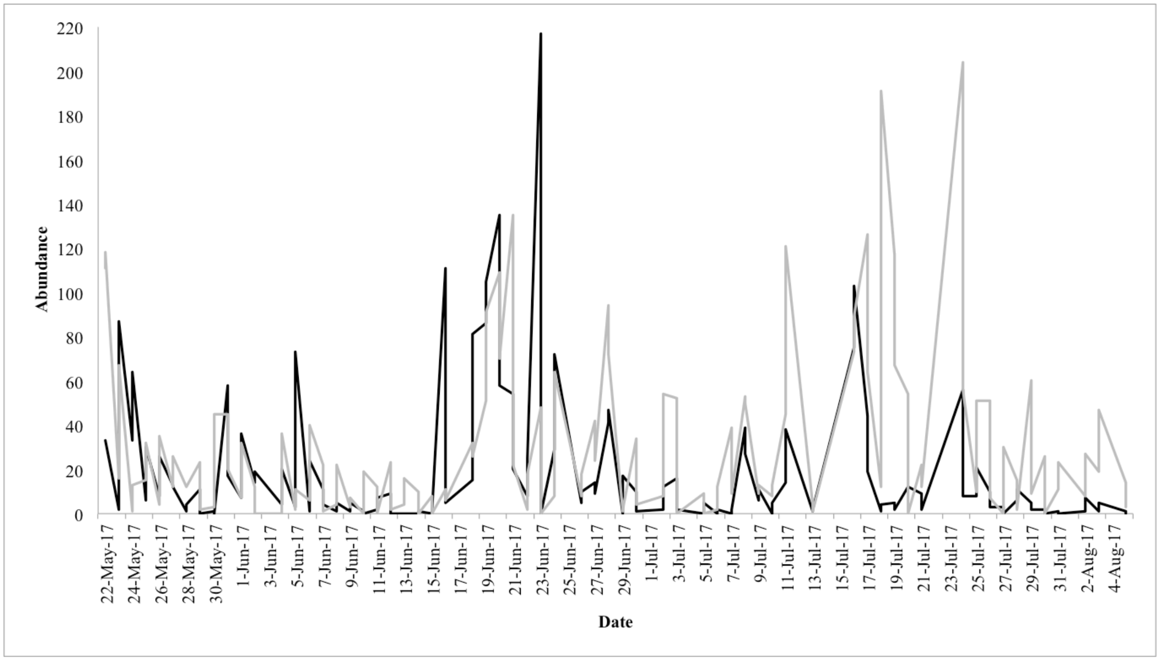

Figure 3. Number of active *G. ruricola* individuals within 500m^2 sections on the coastal (grey line) versus inland (black line) roadsides along Queen's Highway, Grand Cayman during the summer from May 22 to August 5, 2017. Analysis revealed there was a significant difference in *G. ruricola* activity levels between coastal and inland roadsides (Mann-Whitney U test, U=6072.5, p<0.0001).

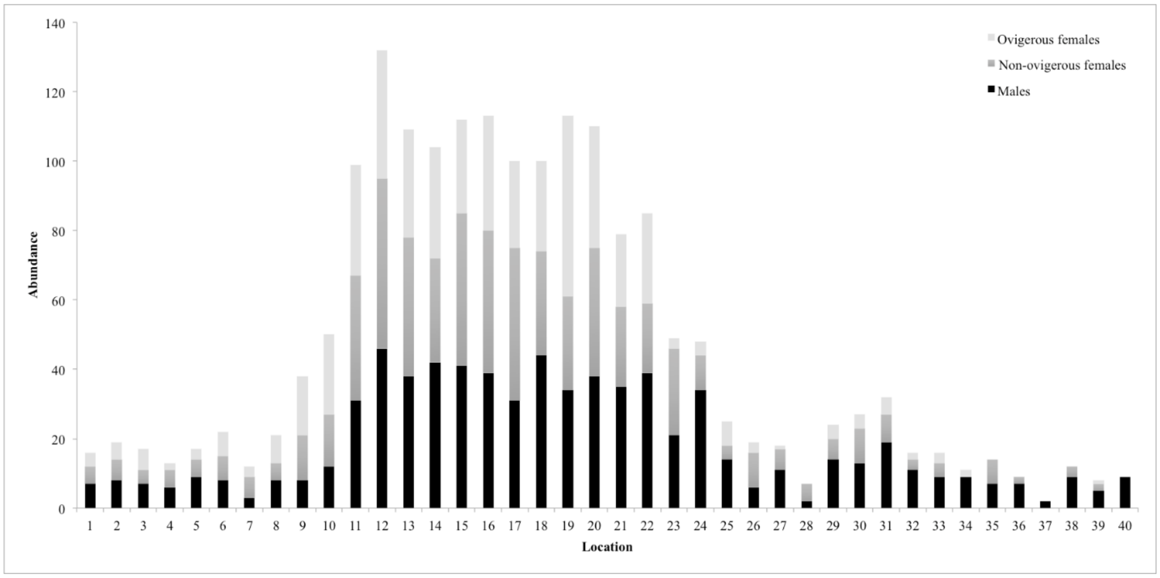

Figure 4. Spatial distribution of *G. ruricola* migrations during the reproductive season from May 22 to August 5, 2017. Males, non-ovigerous females, and ovigerous females along Queen's Highway in each road section (850m^2).

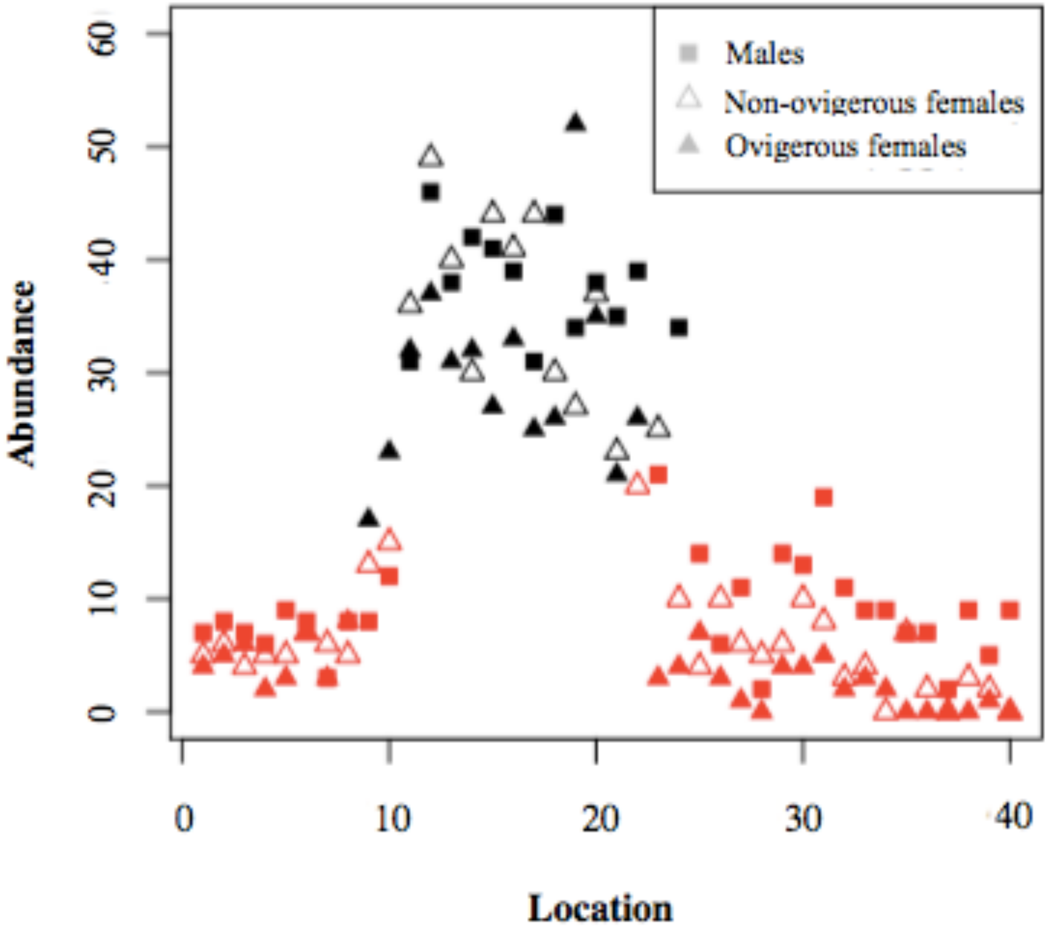

Figure 5. Results of *k*-means clustering indicating there were two clusters of *G. ruricola* individuals along Queen's Highway in 2017. Abundance is the number of individuals documented throughout the entire 12-week study within each of the 40 road sections (location). The data were separated into two different groups based on low and high abundance values. Red depicts cluster one (low cluster mean=6.04 individuals/cluster) and black represents cluster two (high cluster mean=34.38 individuals/cluster).

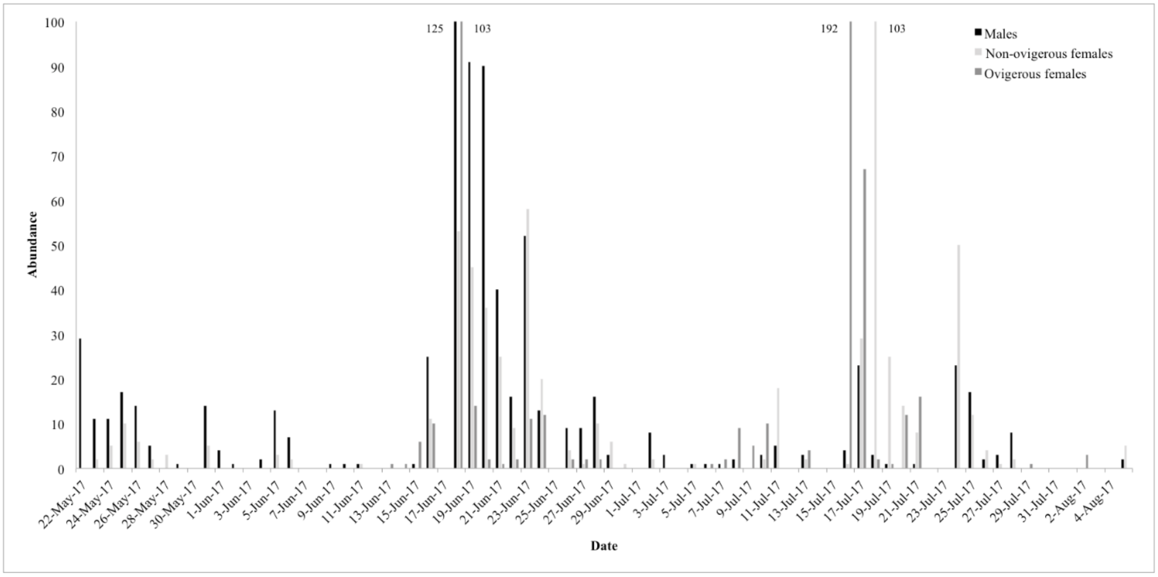

Figure 6. Temporal migration displaying the number of active *G. ruricola* individuals on Queen’s Highway, Grand Cayman throughout the collection dates (May 22 to August 5, 2017). Abundance values for 18 June and 16/18 July exceed the axis scale and values are marked next to the column.

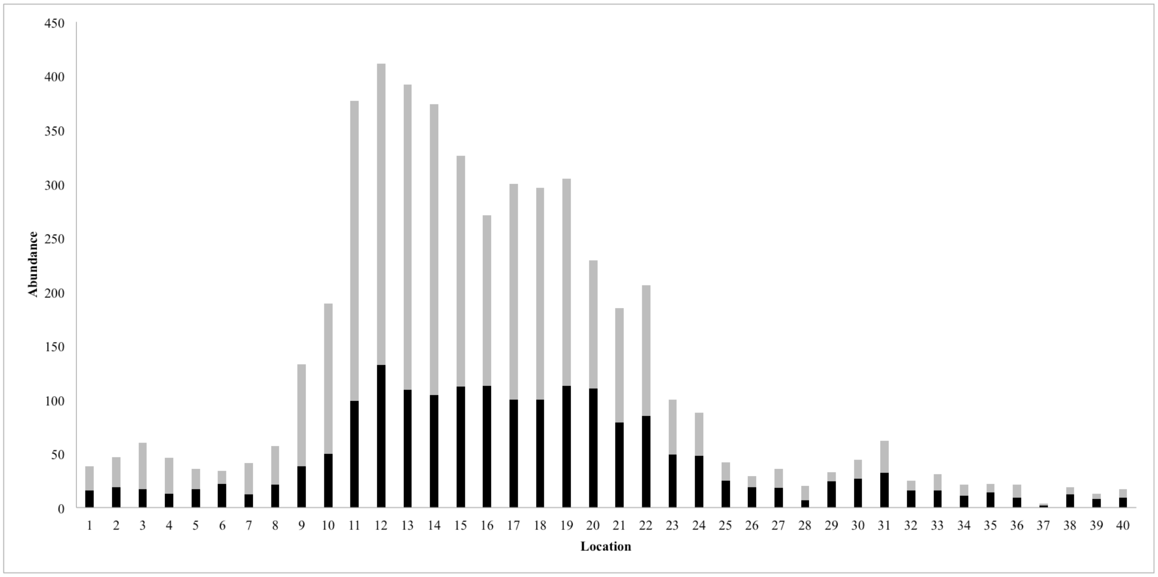

Figure 7. Number of active (black) *G. ruricola* on the road versus roadkills (grey) encountered during the road surveys within each road section (850m^2) along Queen's Highway, Grand Cayman from May 22 to August 5, 2017.

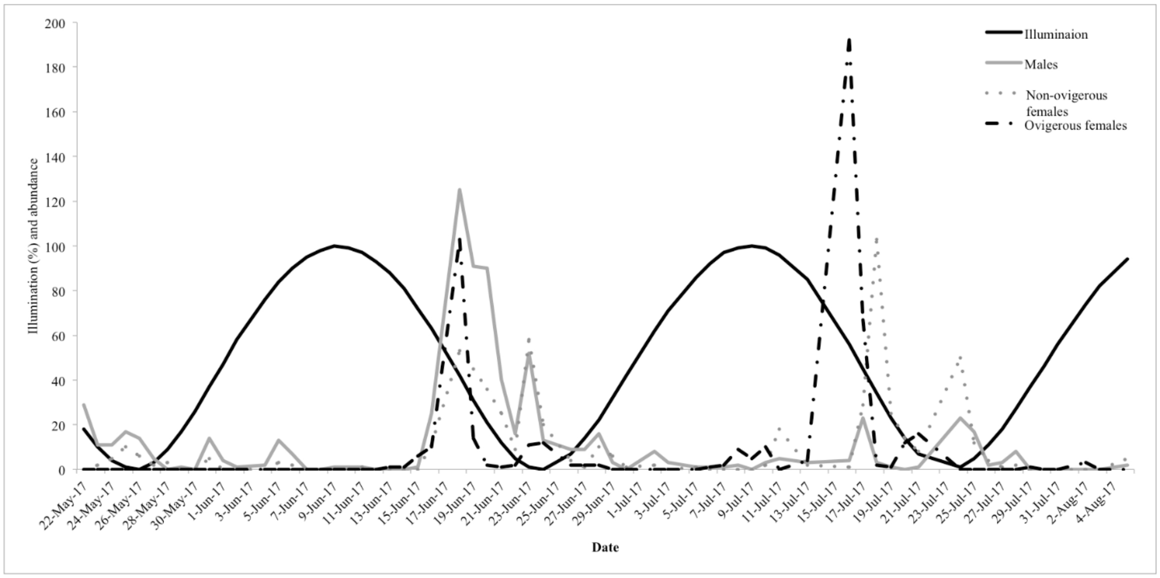

Figure 8. Moon illumination (%) values obtained from the U.S. Naval Observatory and the number of *G. ruricola* individuals encountered on Queen's Highway throughout the 2017 data collection on Grand Cayman. New moons (0-1%) were respectively around 24 June and 24 July 2017. *Gecarcinus ruricola* activity levels were highest during the waning crescent (2-49%) moon phase which took place 18 to 22 June and 17 to 21 July 2017.

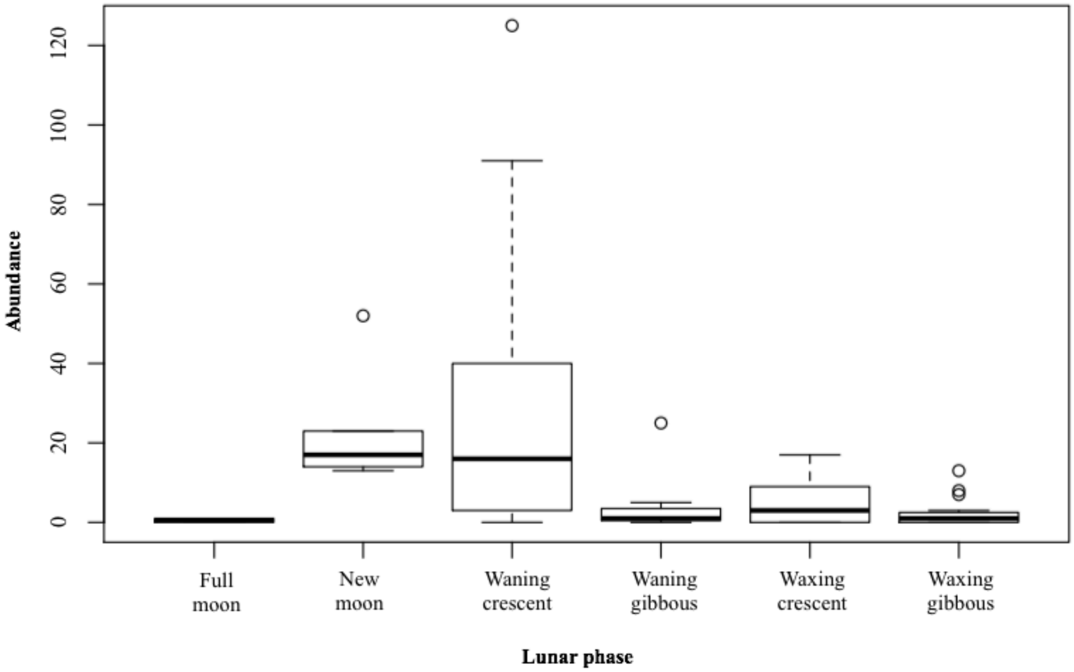

Figure 9. Number of *G. ruricola* males in each lunar phase category for summer 2017 (64 samples). Sample sizes for each lunar phase are as follows (n=736 individuals): Full moon n=1; New moon n=119; Waning crescent n=441; Waning gibbous n=43; Waxing crescent n=91; Waxing gibbous n=41.

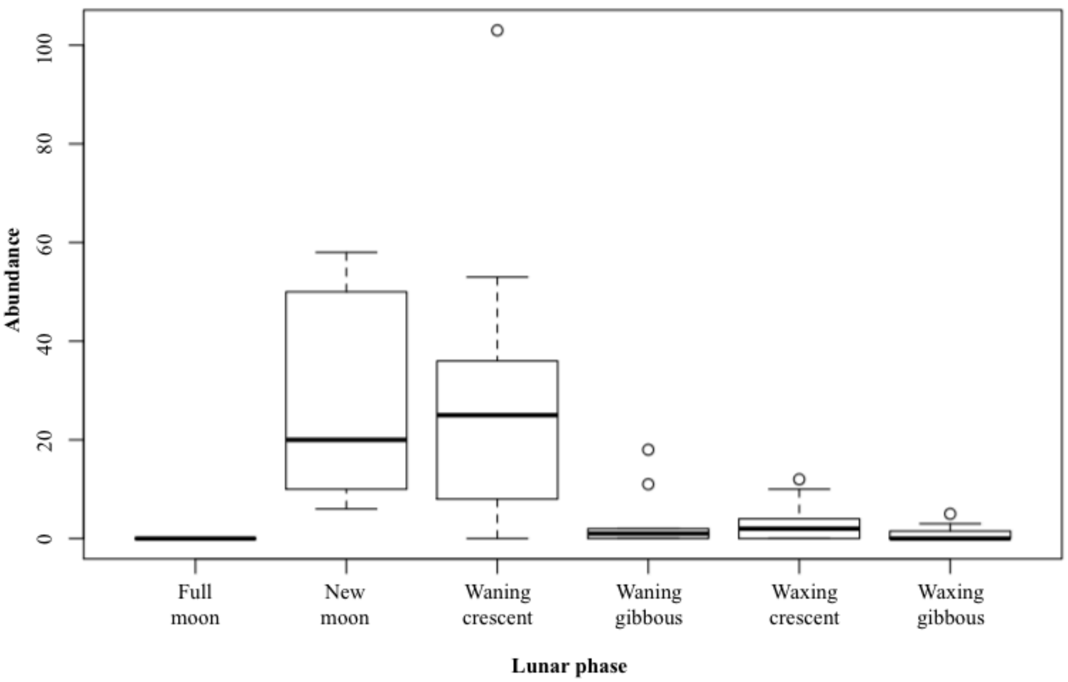

Figure 10. Number of *G. ruricola* non-ovigerous females in each lunar phase category for summer 2017 (64 samples). Sample sizes for each lunar phase are as follows (n=597 individuals): Full moon n=0; New moon n=144; Waning crescent n=354; Waning gibbous n=35; Waxing crescent n=51; Waxing gibbous n=13.

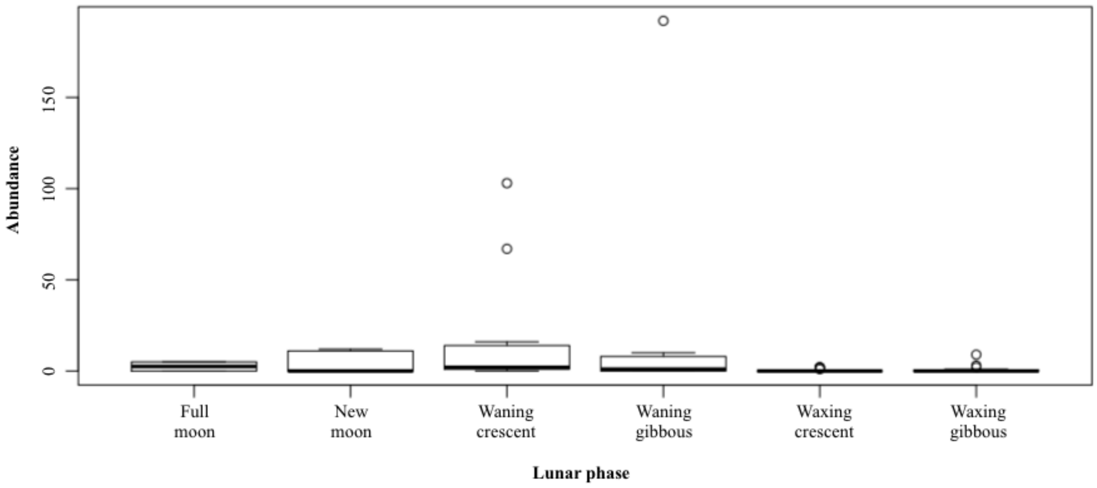

Figure 11. Number of *G. ruricola* ovigerous females in each lunar phase category for summer 2017 (64 samples). Sample sizes for each lunar phase are as follows (n=494 individuals): Full moon n=5; New moon n=23; Waning crescent n=220; Waning gibbous n=224; Waxing crescent n=7; Waxing gibbous n=15.

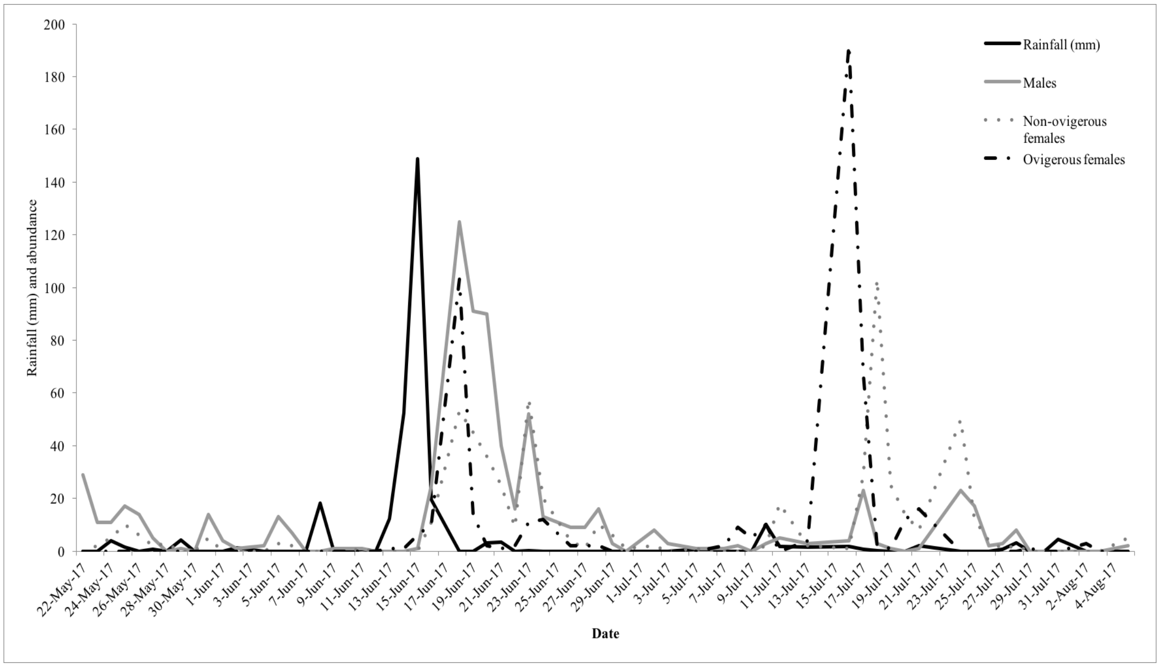

Figure 12. Rainfall amounts (mm) obtained from the Cayman Water Authority and number of active *G. ruricola* recorded on the road during summer 2017 along Queen's Highway, East End, Grand Cayman. A positive correlation was observed between rainfall amount and *G. ruricola* activity levels for both sexes, although results were only statistically significant in males and non-ovigerous females (males: Spearman's rho=0.4294, df=62, p=0.0004; non-ovigerous females: Spearman's rho=0.3390, df=62, p=0.0061)

Figure 13. Drone images of the various road sections within the study area on Queen's Highway, East End, Grand Cayman. A-B) Road sections 15 and 16 comprise sandy pathways along the coastal roadside leading directly to the sea; C-D) Road sections three and seven contain housing development on the coastal and inland roadsides; E) The distance from the water to roadside edge in road section 21 is shorter (distance <0.03km) compared to other sections within the study area; F) Road section 21 with fully-forested *G. ruricola* habitat on both roadsides.

Table 1. Summary of the two clusters (cluster one: low numbers of individuals, cluster two: high numbers of individuals) observed in each sex based on *k*-cluster analyses. Cluster size represents the number of road sections per cluster (total=40), cluster mean is the average number of *G. ruricola* individuals per cluster, and cluster sections represent which specific road sections comprise each cluster.

Sex	Cluster number	Cluster size	Cluster mean	Cluster sections
Males	1	27	9.04	1-10, 23, 25-40
	2	13	37.85	11-22, 24
Non-ovigerous females	1	28	6.12	1-10, 22, 24-40
	2	12	35.50	11-21, 23
Ovigerous females	1	26	2.96	1-8, 23-40
	2	14	29.79	9-22

GENERAL SUMMARY

This research adds to an expanding body of work on the population structure and reproductive migration patterns of land crabs. The two species studied, *Cardisoma guanhumi* (white land crab) and *Gecarcinus ruricola* (black land crab), are ecologically and economically important on Grand Cayman. This section highlights summaries of each chapter, as well as anecdotal information and future studies regarding the land crabs on Grand Cayman. In addition to contributing to the greater understanding of land crabs, this study will be of value to the Cayman Department of Environment. Current populations for *C. guanhumi* and *G. ruricola* are unknown, although they are suspected to be declining in numbers. This data will be shared with the Cayman Department of Environment to provide baseline information and methodology they can use to establish a conservation plan and monitor Cayman's land crab populations in the future. Lastly, the end of this section concludes with implications for conservation involving forthcoming management decisions and/or efforts on the island.

A male-biased sex ratio was observed in the *C. guanhumi* population on Grand Cayman, specifically in the two larger carapace width (CW) size classes (60.0 to 65.0mm and 80.0 to 85.0mm CW) (Chapter 2). The higher number of males was most likely influenced by the surface sampling methodology, as well as the water tolerance, behavior, and sex-specific habitat use in *C. guanhumi* (Herreid 1963, Dunham & Gilchrist 1988, Wolcott 1988). Additionally, environmental factors such as water temperature, salinity levels, and nutrient availability may influence sexual differentiation and determination during larval stages (Jaccarini et al. 1983, Adams et al. 1987, Naylor et al. 1988, Sgro et al. 2002). Generally, *C. guanhumi* males reached a larger body size than females, which is a common trend in brachyuran crabs. These growth differences are due to how each sex allocates energy expenditure (Hartnoll 1988a, Hartnoll 1988b). Four color patterns were observed in males and non-ovigerous females, while ovigerous females only displayed two of the patterns. The color patterns seemed to change as *C. guanhumi* individuals increased in body size, as there were significant differences between the characteristic color pattern for juveniles and each of the remaining color morphs (Gifford 1962, Silva et al. 2014). The habitat preference for *C. guanhumi* on Grand Cayman consists of tidally flooded mangrove forests and woodlands, seagrape hedge, salt-tolerant succulents, and brackish ponds (DaCosta-Cottam et al. 2009). A vegetation survey was conducted at the study area, Barkers National Park, and a list of dominant plant species is located in the appendices.

Gecarcinus ruricola males also reach a larger maximum size than females, for all measured morphometrics on Grand Cayman (Chapter 3). Similar to *C. guanhumi*, this is most likely due to how each sex distributes their energy utilization, as females expend greater resources on reproduction, at the cost of growth (Hartnoll 1988a, Hartnoll 1988b). Overall, both sexes of *G. ruricola* on Grand Cayman seem to be smaller in terms of body size than other populations in the Caribbean (Britton et al. 1982). Furthermore, carapace widths for two ovigerous females from the study were documented to be less than what has been usually considered as sexually mature in literature (Hartnoll et al. 2007). It may be possible the *G. ruricola* populations on Grand Cayman are crowded due to habitat encroachment from development, increasing competition for a limited food supply, thus, limiting body size. In addition, there may be genetic differences in the Cayman *G. ruricola* populations, as well as human exploitation levels favoring larger crabs; each leading to observations of smaller-sized individuals on Grand Cayman (Britton et al. 1982, Hartnoll et al. 2006). The habitat preference for *G. ruricola* on Grand Cayman includes dry forests and woodlands growing among calcareous rock formations (DaCosta-Cottam et al. 2009).

The reproductive migration season, which coincides with the rainy season, extends over three months on Grand Cayman, but the intensity of *G. ruricola* activity varies with time (Chapter 4). In 2017, high roadside activity levels for *G. ruricola* shifted from inland to the coastal edge of Queen's Highway following the first migration peak in June. By remaining on the coastal roadside, crabs were more likely to conserve energy and increase reproductive output (Childress 1972, Bertness 1981, Herreid & Full 1988). There were two mass migrations observed with each resulting in high numbers of crabs crossing the road and high roadkill numbers. *Gecarcinus ruricola* individuals were not randomly scattered along the highway; instead each sex showed a distinct clustering distribution which most likely resulted due to habitat changes from development. During the reproductive season nights, males and non-ovigerous females showed no random pattern in their prevalence, although ovigerous females did exhibit randomness. Those random nights of ovigerous female activity most likely coincided with spawning events. Those activity levels were highest during the waning crescent moon phase which is prior to the new moon. Similar occurrences have been documented in San Andrés where the number of *G. ruricola* females with ripe eggs was higher during periods around the new moon (Hartnoll et al. 2007, Hartnoll et al. 2010). The number of roadkills generally reflected the migration intensity. Moonlight had a significant effect on the number of *G. ruricola* individuals on the road and rainfall enhanced overall activity on Grand Cayman.

It is be valuable to mention *G. ruricola* displays a wide range of color variation, but it is unknown if color patterns are related to the development stage and maturity like *C. guanhumi*. Individuals (>45mm CW) had a combination of white, black, purple, orange, yellow, red, and brown on Grand Cayman. All of the smaller *G. ruricola* individuals (<10mm CW) observed crossing Queen's Highway in 2017 had a solid black carapace and orange legs. It should also be noted during the coastal migration study in 2017, attempts were made to capture every crab seen on the highway, but there were nights when local crabbers were also out collecting crabs. Although this may have slightly influenced overall numbers of *G. ruricola* migrating per night, the roadkill numbers most likely compensated for road sections with the highest activity where crabbers focused their greatest efforts.

Future studies would benefit from obtaining larger sample sizes for *C. guanhumi* and *G. ruricola* to gather additional morphometric data to further investigate growth and color patterns on Grand Cayman. Although collecting specimens by hand seemed to be the most time efficient, it would be purposeful to incorporate other methods such as burrow sampling using baited traps to obtain a more accurate depiction of current populations and sex ratios (Carmona-Suárez & Guerra-Castro 2012). Additionally, studies involving population estimates for *G. ruricola* and *C. guanhumi* are in urgent need. These studies should occur during the reproductive and non-reproductive seasons in order to characterize specific habitat requirements and enable robust population size estimations to adequately assess population numbers in the future. It would also be beneficial to utilize tracking devices to map the movements and migration routes of *G. ruricola* (both on the road and along the shoreline) in order to identify potentially important migratory corridors along Queen’s Highway on Grand Cayman. Internal tagging by PIT tags may be a viable option and has shown to be successful in land crabs (Forsee & Albrecht 2012, Moraes-Costa & Schwamborn 2018). Lastly, an extensive time-series analysis of various environmental factors such as moon illumination, sky conditions, humidity, and rainfall would be beneficial to predict future mass migrations of *G. ruricola* on Grand Cayman.

Implications for conservation

The main threats to land crabs on Grand Cayman are most likely increases in vehicular traffic and light pollution, specifically along Queen’s Highway, habitat loss from development, and overexploitation from humans. Road traffic is an increasing source of mortality for land crabs on Grand Cayman, especially on the nights when crabs are most active. Installation of crab warning signs in the road sections on Queen’s Highway with the highest crab activity levels would alert drivers to the presence of land crabs as an attempt to reduce vehicular caused mortality. An example of these road warning signs have been used on Ascension Island for *Johngarthia lagostoma* (Ascension Island Government 2015). Flashing lights on those signs during nights with high crab activity, as noted from this study during the two migration peak timeframes in June and July, would also draw attention to crabs crossing the highway. In this study, both sexes of *G. ruricola* are migrating several nights before the new moon when the presence of natural light is decreasing and artificial street light remains constant. This is a critical time of the year for ovigerous females, as they may be attracted and/or sensitive to artificial light (Wolcott & Wolcott 1982, Longcore & Rich 2004). It would be beneficial to remove or dim street lights in the high crab activity areas on the road to deter the number of wandering crabs off the road and instead direct them to the sea. If removing street lights was a safety concern, adjusting the spectral composition of white light (e.g., switching from ultraviolet/blue light to red light bulbs) in specific street lights within heavily crab trafficked areas may decrease the number of crabs on the road (Swaddle et al. 2015). A list of those specific road sections on Queen's Highway and their associated GPS coordinates are listed in the appendices.

As migratory animals, land crabs have multiple roles spanning the territories they cross. In the ocean, many animals (e.g., invertebrates, fish, mammals) feed on the crab's larvae as they drift and then settle into the shallow seagrass beds, coral reefs, and mangrove wetlands (Gimenez & Anger 2005, Hobbs et al. 2009). Additionally, land crabs play important roles in forested coastal habitats. Recent research has advanced regarding how to assess and quantify the ecological role that land crabs have as keystone species and engineers in these ecosystems (Lindquist et al. 2009, Rodríguez-Fourquet & Sabat 2009). Land crabs facilitate forest growth and development through various activities such as excavating burrows, creating soil mounds, aerating soil, and removing leaf litter in and out of burrows. Additionally, they feed on, and thus move, seeds, propagules, and seedlings that affect plant establishment and influence the species composition of coastal plant communities (Green 1997, Allen et al. 2003, Lindquist & Carroll 2004, Lindquist et al. 2009, Rodríguez-Fourquet & Sabat 2009). Crabs are also known to scavenge understory by detangling vines and shrubs to allow for new regrowth (Hicks et al. 1990). The loss of a forested habitat is a considerable issue on the island as tourist-related development and urbanization continues. Data indicating locations with the highest crab activity and roadkill numbers along Queen's Highway may be useful to the Cayman Department of Environment for consideration of land to purchase to conserve surrounding areas. Purchasing land would protect and provide habitat for crabs, but also for endemic animals such as the endangered Grand Cayman Blue Iguana (*Cyclura lewisi*), Grand Cayman Blue-throated Anole (*Norops* or *Anolis conspersus*), and Grand Cayman racer snake (*Cubophis caymanus*) (Seidel & Franz 1994, Hartnoll et al. 2014). Additionally, it would protect the national tree, Silver Thatch Palm (*Coccothrinax proctorii*), which is unique to the Cayman Islands (Chapter 3, Proctor 1984).

Both land crab species are harvested on the island, although *C. guanhumi* seems to be consumed on a larger scale than *G. ruricola*. Similar to the management of *G. ruricola* in San Andrés, it may be necessary to implement licensing fees, limit collecting times, or establish bag limits for both species (Baine et al. 2007). Furthermore, the use of minimum size and sex restrictions may be helpful in maintaining healthy populations. This is particularly important for *G. ruricola* because the overall size of mature females may be smaller than what was previously suggested in literature (Chapter 3, Hartnoll et al. 2007). Overexploitation does not seem to be the main threat on Grand Cayman, although if excessive numbers are caught, populations will decline in the near future. The numbers will fall to a level where expending catching effort is no longer worthwhile.

As invertebrates, land crabs have a low public profile and tend to be underrepresented in global conservation efforts. This research discusses the importance of *C. guanhumi* and *G. ruricola* on Grand Cayman, and should be shared with the public to allow further engagement on biodiversity issues involving invertebrates on the island. Public outreach may involve televised news reports, newspaper/internet articles (such as the bimonthly reports in the Cayman Department of Environment's newsletter, *Flicker*) (Bass & Tedford 2015, Tedford 2017), or through pamphlets highlighting a summary of this research would all bring awareness for land crab populations and their protection on Grand Cayman.

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APPENDICES

Appendix AI. Raw data for *Cardisoma guanhumi* (Chapter 2). Mass (g), CW indicates carapace width (mm), chela refers to major chela length (mm), side refers to whether the right or left first pereopod was measured, and color indicates the color pattern number (1-4) referenced from Chapter 2 (n=270).

Date	Mass	CW	Chela	Side	Color	Sex
18-May-16	225	70.8	46.4	Right	3	Male
18-May-16	175	65.6	37.7	Right	2	Male
18-May-16	400	91.8	102.9	Right	2	Male
18-May-16	150	60.9	60.2	Left	2	Male
18-May-16	250	75.2	62.6	Left	2	Non-ovigerous female
18-May-16	110	54.0	48.6	Right	2	Non-ovigerous female
18-May-16	150	59.6	43.7	Right	2	Non-ovigerous female
18-May-16	170	63.7	63.5	Right	1	Male
18-May-16	175	65.5	29.4	Right	1	Non-ovigerous female
18-May-16	170	68.3	63.2	Left	1	Non-ovigerous female
20-May-16	225	73.6	66.6	Right	3	Male
20-May-16	485	98.9	124	Right	3	Male
20-May-16	235	71.5	86.8	Left	2	Male
20-May-16	265	73.2	52.4	Right	2	Male
21-May-16	375	96.2	69.6	Right	2	Ovigerous female
22-May-16	225	76.9	70.4	Right	3	Male
22-May-16	185	74.1	71.7	Left	2	Male
22-May-16	200	79.0	54.9	Left	2	Male
22-May-16	230	72.5	78.0	Left	2	Male
22-May-16	250	82.2	84.0	Right	2	Male
22-May-16	235	81.1	77.3	Right	2	Male
22-May-16	225	78.4	65.4	Left	2	Non-ovigerous female
22-May-16	350	90.8	76.6	Left	2	Ovigerous female
22-May-16	185	76.4	65.2	Left	1	Non-ovigerous female
24-May-16	385	90.9	104.8	Right	3	Male
24-May-16	275	80.8	81.2	Left	2	Male
24-May-16	85	58.9	28.4	Right	2	Male
24-May-16	150	66.4	63.5	Left	2	Male
24-May-16	145	65.7	57.1	Left	2	Non-ovigerous female
24-May-16	200	75.7	52.1	Right	2	Ovigerous female
26-May-16	325	89.9	113.6	Right	3	Male
26-May-16	165	71.0	57.2	Right	2	Male
26-May-16	285	84.0	90.3	Left	2	Male
26-May-16	205	72.0	56.0	Left	2	Non-ovigerous female
26-May-16	215	82.0	69.3	Left	2	Non-ovigerous female

Appendix A1 (continued). Raw data for *Cardisoma guanhumi* (Chapter 2).

Date	Mass	CW	Chela	Side	Color	Sex
26-May-16	200	80.2	68.3	Left	2	Non-ovigerous female
26-May-16	225	81.8	68.5	Left	2	Non-ovigerous female
26-May-16	100	61.2	53.0	Right	1	Male
26-May-16	165	72.1	68.9	Right	1	Male
26-May-16	285	83.3	98.2	Right	4	Male
31-May-16	275	83.0	78.3	Left	3	Male
31-May-16	265	83.0	84.0	Right	2	Male
31-May-16	225	76.8	77.9	Right	2	Male
31-May-16	125	67.6	38.2	Right	2	Non-ovigerous female
31-May-16	285	83.9	74.2	Left	2	Non-ovigerous female
31-May-16	295	87.2	70.2	Right	2	Non-ovigerous female
31-May-16	350	86.4	79.6	Left	2	Ovigerous female
31-May-16	175	72.1	61.5	Left	1	Non-ovigerous female
31-May-16	100	58.2	46.4	Right	1	Non-ovigerous female
31-May-16	225	76.4	58.1	Right	4	Non-ovigerous female
2-Jun-16	365	89.0	106.7	Right	2	Male
2-Jun-16	285	84.0	83.6	Right	2	Male
2-Jun-16	300	82.4	89.5	Left	2	Male
2-Jun-16	275	82.9	58.9	Right	2	Non-ovigerous female
2-Jun-16	255	78.0	67.9	Right	2	Non-ovigerous female
2-Jun-16	165	71.4	44.1	Right	2	Non-ovigerous female
2-Jun-16	225	70.9	61.8	Left	2	Non-ovigerous female
2-Jun-16	185	72.7	57.5	Right	2	Non-ovigerous female
2-Jun-16	5	38.2	27.0	Left	1	Male
2-Jun-16	285	81.8	64.9	Right	1	Non-ovigerous female
6-Jun-16	415	97.0	114.1	Left	2	Male
6-Jun-16	175	69.5	52.5	Right	2	Male
6-Jun-16	255	82.7	77.0	Right	2	Male
6-Jun-16	215	76.1	83.2	Right	2	Male
6-Jun-16	265	79.1	79.5	Left	2	Male
6-Jun-16	285	83.1	67.6	Left	2	Non-ovigerous female
6-Jun-16	185	73.1	59.5	Right	2	Non-ovigerous female
6-Jun-16	165	68.2	60.1	Right	2	Non-ovigerous female
6-Jun-16	80	63.3	32.4	Right	1	Non-ovigerous female
9-Jun-16	225	70.2	87.7	Right	2	Male
9-Jun-16	275	80.5	84.8	Left	2	Male
9-Jun-16	165	63.8	52.6	Left	2	Male
9-Jun-16	175	70.5	68.9	Right	2	Male
9-Jun-16	575	104.9	138.2	Right	2	Male
9-Jun-16	365	95.0	78.2	Left	2	Non-ovigerous female
9-Jun-16	220	71.6	62.6	Right	2	Non-ovigerous female
9-Jun-16	75	54.0	43.6	Right	2	Non-ovigerous female
9-Jun-16	120	58.6	47.2	Right	1	Male

Appendix A1 (continued). Raw data for *Cardisoma guanhumi* (Chapter 2).

Date	Mass	CW	Chela	Side	Color	Sex
9-Jun-16	300	86.6	77.8	Left	4	Male
10-Jun-16	285	86.4	65.6	Left	3	Ovigerous female
10-Jun-16	175	73.8	62.7	Right	2	Male
10-Jun-16	325	83.7	90.6	Left	2	Male
10-Jun-16	325	93.2	97.0	Left	2	Male
10-Jun-16	325	88.7	78.1	Left	2	Ovigerous female
10-Jun-16	175	71.7	62.0	Right	1	Male
10-Jun-16	75	49.7	42.3	Left	1	Male
10-Jun-16	135	64.6	64.2	Right	1	Male
10-Jun-16	125	57.6	48.3	Right	1	Non-ovigerous female
13-Jun-16	250	75.2	75.4	Right	2	Male
13-Jun-16	175	71.5	53.9	Right	2	Non-ovigerous female
13-Jun-16	185	73.6	72.7	Right	1	Male
13-Jun-16	265	80.5	68.4	Right	1	Non-ovigerous female
13-Jun-16	335	88.0	74.5	Left	1	Non-ovigerous female
14-Jun-16	195	73.8	67.2	Left	3	Male
14-Jun-16	400	73.3	109.4	Right	3	Male
14-Jun-16	265	82.2	82.2	Left	2	Male
14-Jun-16	175	65.9	57.9	Left	2	Male
14-Jun-16	325	73.2	71.2	Right	2	Male
14-Jun-16	365	80.7	83.6	Left	2	Male
14-Jun-16	335	78.0	78.3	Left	2	Male
14-Jun-16	320	86.6	73.4	Left	1	Male
14-Jun-16	235	80.9	74.0	Right	1	Male
14-Jun-16	345	78.4	52.0	Right	1	Male
16-Jun-16	245	79.2	77.9	Left	3	Male
16-Jun-16	275	79.4	90.4	Left	3	Male
16-Jun-16	235	75.6	72.7	Right	2	Male
16-Jun-16	200	72.6	65.4	Right	2	Male
16-Jun-16	210	71.1	79.2	Right	2	Male
16-Jun-16	235	80.6	60.8	Right	2	Non-ovigerous female
16-Jun-16	175	68.9	64.4	Left	2	Ovigerous female
16-Jun-16	135	62.1	56.5	Right	1	Male
16-Jun-16	215	70.1	62.3	Left	4	Male
16-Jun-16	275	83.2	82.2	Left	4	Non-ovigerous female
20-Jun-16	165	66.0	55.2	Left	2	Male
20-Jun-16	305	89.3	98.1	Left	2	Male
20-Jun-16	125	68.2	57.1	Left	2	Non-ovigerous female
20-Jun-16	200	74.2	66.3	Left	2	Non-ovigerous female
20-Jun-16	150	73.0	44.9	Right	2	Non-ovigerous female
20-Jun-16	185	76.1	59.7	Left	2	Ovigerous female
20-Jun-16	115	59.1	51.9	Left	1	Male
20-Jun-16	75	56.5	48.2	Right	1	Male

Appendix A1 (continued). Raw data for *Cardisoma guanhumi* (Chapter 2).

Date	Mass	CW	Chela	Side	Color	Sex
21-Jun-16	285	81.0	77.7	Right	3	Male
21-Jun-16	165	70.9	52.0	Right	2	Male
21-Jun-16	95	55.9	48.5	Right	2	Male
21-Jun-16	220	74.5	71.1	Right	2	Male
21-Jun-16	190	73.0	67.4	Left	2	Male
21-Jun-16	295	87.0	93.4	Right	2	Male
21-Jun-16	165	65.4	48.1	Right	2	Non-ovigerous female
21-Jun-16	125	59.9	54.5	Left	1	Male
21-Jun-16	250	66.0	43.8	Left	1	Non-ovigerous female
21-Jun-16	85	52.5	46.4	Left	1	Non-ovigerous female
23-Jun-16	425	94.0	120	Right	3	Male
23-Jun-16	420	98.0	100	Right	2	Male
23-Jun-16	125	57.6	44.1	Right	2	Non-ovigerous female
23-Jun-16	225	76.0	58.6	Left	2	Non-ovigerous female
23-Jun-16	165	42.5	46.6	Left	1	Male
23-Jun-16	125	58.8	50.3	Right	1	Male
26-Jun-16	265	83.6	58.3	Right	2	Non-ovigerous female
26-Jun-16	325	92.3	77.2	Right	2	Ovigerous female
26-Jun-16	420	96.1	77.3	Right	2	Ovigerous female
27-Jun-16	275	78.4	78.4	Left	3	Male
27-Jun-16	175	68.5	64.4	Right	3	Male
27-Jun-16	225	74.4	76.2	Left	3	Male
27-Jun-16	175	74.5	53.1	Left	3	Male
27-Jun-16	175	66.8	53.5	Left	3	Male
27-Jun-16	200	72.9	71.1	Left	2	Male
27-Jun-16	285	80.7	82.7	Right	2	Male
27-Jun-16	265	79.2	71.7	Right	2	Male
27-Jun-16	225	73.2	63.4	Left	2	Non-ovigerous female
27-Jun-16	175	72.9	47.1	Left	2	Non-ovigerous female
28-Jun-16	190	79.0	72.2	Right	2	Male
28-Jun-16	150	63.7	52.5	Right	2	Male
28-Jun-16	100	59.1	51.7	Left	2	Non-ovigerous female
28-Jun-16	145	66.1	57.9	Right	1	Male
29-Jun-16	360	90.3	78.0	Right	2	Non-ovigerous female
29-Jun-16	350	92.9	78.8	Right	2	Ovigerous female
30-Jun-16	400	106	81.9	Right	2	Non-ovigerous female
1-Jul-16	310	84.0	95.3	Right	3	Male
1-Jul-16	100	54.2	47.1	Right	2	Male
1-Jul-16	190	59.4	52.0	Right	2	Male
1-Jul-16	240	77.4	73.4	Left	2	Male
1-Jul-16	165	70.8	41.2	Right	2	Non-ovigerous female
1-Jul-16	125	60.9	55.6	Left	1	Male
1-Jul-16	295	85.1	82.3	Right	1	Male

Appendix A1 (continued). Raw data for *Cardisoma guanhumi* (Chapter 2).

Date	Mass	CW	Chela	Side	Color	Sex
1-Jul-16	110	57.4	45.5	Left	1	Non-ovigerous female
1-Jul-16	250	81.5	60.6	Left	1	Non-ovigerous female
1-Jul-16	220	74.1	76.1	Right	4	Male
6-Jul-16	190	73.0	57.6	Left	3	Non-ovigerous female
6-Jul-16	125	63.1	53.3	Left	2	Male
6-Jul-16	200	74.5	80.6	Left	2	Male
6-Jul-16	300	81.5	84.2	Left	2	Male
6-Jul-16	150	62.1	51.6	Left	2	Male
6-Jul-16	300	82.2	92.3	Left	2	Male
6-Jul-16	290	77.1	95.3	Left	2	Male
6-Jul-16	250	93.2	72.5	Right	2	Non-ovigerous female
6-Jul-16	245	79.0	43.1	Left	2	Ovigerous female
6-Jul-16	220	72.4	71.8	Right	4	Male
8-Jul-16	225	75.6	79.0	Right	3	Male
8-Jul-16	250	77.0	68.9	Left	2	Male
8-Jul-16	250	91.4	67.1	Left	2	Non-ovigerous female
8-Jul-16	210	73.5	53.5	Left	2	Non-ovigerous female
8-Jul-16	160	69.6	51.5	Left	2	Ovigerous female
8-Jul-16	5	32.1	15.2	Left	1	Male
8-Jul-16	100	56.6	44.7	Right	1	Male
8-Jul-16	100	60.2	45.4	Left	1	Non-ovigerous female
8-Jul-16	215	74.0	66.8	Left	4	Male
11-Jul-16	290	81.3	81.3	Left	3	Male
11-Jul-16	290	79.6	79.6	Left	3	Male
11-Jul-16	180	71.3	51.7	Right	3	Non-ovigerous female
11-Jul-16	145	65.9	48.8	Right	2	Male
11-Jul-16	210	73.8	69.1	Left	2	Male
11-Jul-16	250	74.0	76.0	Right	2	Male
11-Jul-16	300	79.3	84.9	Right	2	Male
11-Jul-16	275	89.4	50.7	Left	2	Non-ovigerous female
11-Jul-16	200	55.0	55.0	Right	2	Non-ovigerous female
11-Jul-16	220	80.0	62.1	Right	4	Non-ovigerous female
13-Jul-16	150	69.9	65.7	Left	2	Male
13-Jul-16	125	62.6	52.9	Right	2	Male
13-Jul-16	145	68.1	66.7	Right	2	Male
13-Jul-16	250	80.3	78.3	Right	4	Male
16-Jul-16	200	69.4	72.3	Left	3	Male
16-Jul-16	410	79.0	116.1	Left	3	Male
16-Jul-16	545	96.1	130.0	Right	3	Male
16-Jul-16	400	92.6	104.8	Right	3	Male
16-Jul-16	200	76.0	61.9	Left	3	Male
16-Jul-16	225	73.5	66.8	Left	2	Male
16-Jul-16	190	71.0	43.6	Left	2	Non-ovigerous female

Appendix A1 (continued). Raw data for *Cardisoma guanhumi* (Chapter 2).

Date	Mass	CW	Chela	Side	Color	Sex
16-Jul-16	145	59.1	49.3	Left	1	Male
16-Jul-16	100	58.6	51.0	Right	1	Non-ovigerous female
18-Jul-16	150	64.0	54.2	Left	3	Male
18-Jul-16	375	89.9	115.6	Left	3	Male
18-Jul-16	175	68.0	64.5	Left	2	Male
18-Jul-16	245	74.1	68.9	Right	2	Non-ovigerous female
18-Jul-16	200	70.2	61.8	Right	2	Non-ovigerous female
18-Jul-16	150	63.9	58.4	Left	1	Male
18-Jul-16	110	60.8	50.8	Left	1	Non-ovigerous female
18-Jul-16	255	75.9	73.6	Left	4	Male
18-Jul-16	500	98.3	131.7	Right	4	Male
18-Jul-16	400	93.0	108.8	Right	4	Male
20-Jul-16	200	74.3	68.1	Right	3	Male
20-Jul-16	150	65.9	52.2	Right	2	Non-ovigerous female
20-Jul-16	5	15.5	7.7	Right	1	Male
25-Jul-16	300	87.8	61.5	Right	3	Male
25-Jul-16	200	76.5	69.7	Right	3	Male
25-Jul-16	300	82.5	75.1	Right	3	Male
25-Jul-16	400	91.4	111.8	Right	3	Male
25-Jul-16	250	75.9	82.1	Left	3	Male
25-Jul-16	150	66.3	57.9	Right	2	Male
25-Jul-16	50	49.5	38.9	Right	1	Non-ovigerous female
25-Jul-16	105	56.2	48.7	Left	1	Non-ovigerous female
25-Jul-16	120	64.0	59.8	Right	4	Male
25-Jul-16	275	85.6	69.9	Left	4	Non-ovigerous female
29-Jul-16	250	80.2	83.1	Left	2	Male
29-Jul-16	300	81.6	87.7	Left	2	Male
29-Jul-16	160	68.8	48.4	Right	2	Non-ovigerous female
29-Jul-16	190	72.8	61.4	Left	2	Non-ovigerous female
29-Jul-16	100	65.7	54.8	Right	1	Male
29-Jul-16	150	64.4	56.3	Left	1	Male
29-Jul-16	150	74.8	69.4	Right	1	Male
29-Jul-16	100	60.9	38.6	Left	1	Non-ovigerous female
29-Jul-16	325	82.9	93.7	Right	4	Male
31-Jul-16	200	73.1	76.9	Left	3	Male
31-Jul-16	200	76.7	68.9	Left	2	Male
31-Jul-16	250	92.4	92.4	Left	2	Male
31-Jul-16	100	65.7	49.0	Right	2	Male
31-Jul-16	210	76.2	74.8	Left	2	Non-ovigerous female
31-Jul-16	190	77.0	63.1	Left	2	Non-ovigerous female
31-Jul-16	240	78.8	62.2	Right	2	Non-ovigerous female
31-Jul-16	75	51.9	32.3	Left	1	Non-ovigerous female
31-Jul-16	75	52.7	43.7	Right	1	Non-ovigerous female

Appendix A1 (continued). Raw data for *Cardisoma guanhumi* (Chapter 2).

Date	Mass	CW	Chela	Side	Color	Sex
31-Jul-16	125	63.9	57.7	Left	1	Male
1-Aug-16	200	72.9	59.2	Right	3	Non-ovigerous female
1-Aug-16	300	83.7	90.9	Right	2	Male
1-Aug-16	200	72.4	67.3	Right	2	Male
1-Aug-16	110	54.1	43.0	Right	2	Non-ovigerous female
1-Aug-16	275	79.1	70.2	Left	2	Non-ovigerous female
1-Aug-16	190	69.3	51.8	Left	2	Non-ovigerous female
1-Aug-16	245	79.7	53.6	Left	2	Non-ovigerous female
1-Aug-16	250	74.6	65.1	Left	2	Ovigerous female
1-Aug-16	100	59.4	33.2	Left	1	Male
4-Aug-16	300	81.7	99.6	Left	3	Male
4-Aug-16	200	71.7	73.0	Right	3	Male
4-Aug-16	300	87.3	96.7	Right	3	Male
4-Aug-16	200	72.7	57.3	Right	3	Ovigerous female
4-Aug-16	375	91.4	97.1	Right	2	Male
4-Aug-16	350	88.5	110.8	Left	2	Male
4-Aug-16	180	72.7	61.2	Right	2	Non-ovigerous female
4-Aug-16	240	81.9	61.1	Right	2	Non-ovigerous female
4-Aug-16	175	74.6	63.6	Left	2	Non-ovigerous female
4-Aug-16	175	68.8	61.6	Left	4	Male

Appendix A2. Raw data for *Gecarcinus ruricola* (Chapter 3). Mass (g), CW indicates carapace width (mm), CL indicates carapace length (mm), IO indicates interorbital distance (mm), FO refers to fronto-orbital distance (mm), chela refers to major chela length (mm), and side refers to whether the right or left first pereopod was measured. If heterochely (when one claw is larger than the other) was not easily observed, an average of the right and left chela was recorded and the side is "unknown". For sex, M indicates male, NF is non-ovigerous female, and OF represents ovigerous female (n=289).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
19-May-16	165	82.6	--	--	--	63.9	Right	M
19-May-16	215	85.3	--	--	--	77.9	Left	M
19-May-16	185	83.2	--	--	--	73.0	Unknown	M
19-May-16	225	87.2	--	--	--	69.1	Right	NF
21-May-16	150	77.7	--	--	--	71.5	Left	M
23-May-16	50	57.2	--	--	--	35.7	Left	M
23-May-16	185	82.4	--	--	--	63.1	Right	M
23-May-16	135	73.5	--	--	--	51.5	Right	M
23-May-16	135	75.0	--	--	--	53.8	Right	M
23-May-16	125	76.4	--	--	--	45.0	Unknown	NF
23-May-16	225	92.1	--	--	--	58.1	Left	NF
23-May-16	75	71.0	--	--	--	41.8	Left	NF
25-May-16	225	89.3	--	--	--	79.5	Left	M
25-May-16	175	77.3	--	--	--	56.3	Right	M
25-May-16	225	83.7	--	--	--	67.4	Left	M
25-May-16	225	83.7	--	--	--	70.3	Right	M
25-May-16	235	87.3	--	--	--	70.0	Left	M
25-May-16	265	91.4	--	--	--	85.2	Left	M
25-May-16	215	81.6	--	--	--	66.7	Left	M
25-May-16	150	78.9	--	--	--	49.5	Right	NF
25-May-16	165	78.7	--	--	--	47.0	Left	NF
25-May-16	150	79.3	--	--	--	46.2	Unknown	NF
27-May-16	175	73.2	--	--	--	62.1	Right	M
27-May-16	125	68.5	--	--	--	46.0	Right	NF
27-May-16	129	76.1	--	--	--	44.2	Right	NF
27-May-16	100	65.5	--	--	--	39.5	Right	OF
30-May-16	165	75.3	--	--	--	61.0	Left	M
30-May-16	135	77.4	--	--	--	45.3	Right	M
30-May-16	215	81.1	--	--	--	75.3	Left	M
30-May-16	185	74.4	--	--	--	57.4	Left	M
30-May-16	125	70.2	--	--	--	50.1	Unknown	M

Appendix A2 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
30-May-16	250	89.5	--	--	--	73.7	Left	M
30-May-16	155	78.6	--	--	--	57.9	Unknown	M
30-May-16	225	83.1	--	--	--	72.5	Right	M
30-May-16	175	78.1	--	--	--	60.0	Left	M
30-May-16	185	82.1	--	--	--	61.4	Right	NF
1-Jun-16	150	75.0	--	--	--	59.0	Left	M
1-Jun-16	200	82.0	--	--	--	70.0	Right	M
1-Jun-16	150	75.0	--	--	--	61.0	Right	M
1-Jun-16	215	81.0	--	--	--	68.0	Left	M
1-Jun-16	275	95.0	--	--	--	85.0	Left	M
1-Jun-16	165	80.0	--	--	--	71.0	Left	M
1-Jun-16	235	89.0	--	--	--	61.0	Left	M
1-Jun-16	175	73.0	--	--	--	73.0	Right	M
1-Jun-16	165	81.0	--	--	--	50.0	Left	NF
1-Jun-16	125	74.0	--	--	--	41.0	Left	NF
3-Jun-16	275	94.2	--	--	--	81.2	Right	M
3-Jun-16	200	81.5	--	--	--	56.3	Left	M
3-Jun-16	225	85.2	--	--	--	72.1	Left	M
3-Jun-16	265	85.6	--	--	--	85.4	Right	M
3-Jun-16	175	79.7	--	--	--	55.4	Right	M
3-Jun-16	125	70.0	--	--	--	36.5	Right	M
3-Jun-16	135	69.1	--	--	--	39.8	Left	NF
3-Jun-16	155	73.9	--	--	--	48.6	Right	NF
3-Jun-16	115	57.8	--	--	--	44.3	Left	NF
7-Jun-16	155	76.5	--	--	--	56.7	Left	M
7-Jun-16	180	82.9	--	--	--	62.7	Left	M
7-Jun-16	215	83.9	--	--	--	77.3	Right	M
7-Jun-16	225	83.0	--	--	--	86.3	Right	M
7-Jun-16	175	82.2	--	--	--	60.4	Left	M
7-Jun-16	175	74.7	--	--	--	65.4	Left	M
7-Jun-16	195	79.9	--	--	--	72.4	Right	M
7-Jun-16	115	76.5	--	--	--	41.1	Left	NF
7-Jun-16	165	77.4	--	--	--	46.7	Unknown	NF
7-Jun-16	120	73.3	--	--	--	39.8	Unknown	NF
8-Jun-16	120	73.0	--	--	--	55.9	Right	M
8-Jun-16	175	83.0	--	--	--	62.6	Right	M
8-Jun-16	200	82.8	--	--	--	73.2	Left	M
8-Jun-16	220	85.4	--	--	--	69.3	Right	M
8-Jun-16	135	74.7	--	--	--	44.7	Unknown	NF
8-Jun-16	135	73.9	--	--	--	44.6	Unknown	NF
8-Jun-16	130	72.4	--	--	--	54.3	Right	NF
8-Jun-16	135	73.8	--	--	--	47.0	Unknown	NF
8-Jun-16	165	82.4	--	--	--	50.0	Left	NF

Appendix A2 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
8-Jun-16	220	88.2	--	--	--	58.3	Left	NF
11-Jun-16	200	81.8	60.0	12.2	37.1	64.3	Left	M
11-Jun-16	265	78.3	60.7	12.8	34.5	67.1	Right	M
11-Jun-16	185	82.5	61.4	15.0	34.0	61.6	Unknown	M
11-Jun-16	200	83.9	62.1	13.3	35.0	66.7	Left	M
11-Jun-16	225	86.6	62.6	12.4	34.7	73.1	Right	M
11-Jun-16	225	86.1	64.4	13.8	37.6	82.5	Right	M
11-Jun-16	185	82.9	63.4	14.5	42.5	74.6	Right	M
11-Jun-16	125	72.3	55.0	10.7	32.1	42.3	Unknown	NF
11-Jun-16	150	73.8	58.5	13.6	34.2	46.8	Right	NF
11-Jun-16	90	67.1	50.6	11.2	26.9	33.2	Right	NF
15-Jun-16	165	74.0	56.9	11.4	33.1	65.1	Left	M
15-Jun-16	235	89.3	65.8	12.5	36.4	79.1	Left	M
15-Jun-16	200	78.6	59.1	10.7	35.6	67.1	Left	M
15-Jun-16	185	79.5	56.8	12.4	37.3	74.4	Left	M
15-Jun-16	180	79.9	59.7	13.8	34.7	67.1	Left	M
15-Jun-16	200	84.8	63.7	12.4	38.7	71.5	Right	M
15-Jun-16	175	73.4	55.0	9.9	34.1	50.7	Right	M
15-Jun-16	190	80.1	60.1	12.9	36.8	59.8	Left	M
15-Jun-16	235	90.6	64.2	12.5	37.9	88.9	Right	M
15-Jun-16	135	70.9	56.9	10.7	35.6	44.9	Unknown	NF
17-Jun-16	175	80	54.2	9.5	35.2	67.6	Left	M
17-Jun-16	250	86.9	61.8	12.7	39.1	71.0	Right	M
17-Jun-16	165	77.9	58	8.6	33.4	71.7	Right	M
17-Jun-16	190	81.6	60.6	8.2	33.9	62.3	Unknown	M
17-Jun-16	255	89.9	66.8	10.5	38.2	66.8	Left	M
17-Jun-16	235	83.1	64.2	9.7	36.9	60.0	Left	M
17-Jun-16	135	74.5	56.5	10.0	31.4	54.7	Left	M
17-Jun-16	165	78.1	63.0	11.5	32.1	58.7	Unknown	M
17-Jun-16	225	87.5	62.9	10.3	34.4	64.4	Right	M
17-Jun-16	125	73.5	53.3	10.0	32.4	40.0	Unknown	NF
22-Jun-16	220	85.7	64.0	9.9	38.2	73.5	Left	M
22-Jun-16	195	80.0	62.8	9.6	35.8	62.7	Unknown	M
22-Jun-16	185	78.5	58.5	12.6	32.1	65.2	Right	M
22-Jun-16	225	86.6	63.9	9.2	35.2	69.6	Left	M
22-Jun-16	215	84.9	63.7	8.9	36.6	59.8	Left	M
22-Jun-16	225	86.3	64.5	11.3	36.6	61.1	Right	M
22-Jun-16	165	77.3	58.2	9.7	35.8	51.9	Unknown	M
22-Jun-16	225	85.7	62.2	11.7	34.5	64.1	Right	M
22-Jun-16	225	85.6	62.5	10.6	38.8	64.8	Right	M
22-Jun-16	70	77.2	59.8	9.3	34.1	44	Unknown	NF
24-Jun-16	225	85.2	63.8	10.0	35.0	73.9	Left	M
24-Jun-16	250	80.8	65.4	8.8	36.3	72.7	Right	M

Appendix A2 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
24-Jun-16	315	92.5	72.1	12.7	41.0	89.2	Right	M
24-Jun-16	235	91.4	62.8	11.6	39.3	68.0	Left	M
24-Jun-16	175	78.1	59.7	11.2	33.8	57.1	Unknown	M
24-Jun-16	175	77.1	55.4	7.7	30.1	54.6	Right	M
24-Jun-16	255	85.5	65.6	9.9	38.2	74.4	Left	M
24-Jun-16	250	85.6	63.3	10.0	37.6	65.5	Left	M
24-Jun-16	125	75.7	56.2	10.8	34.3	43	Unknown	NF
24-Jun-16	135	76.2	57.8	9.2	32.1	40.5	Unknown	NF
26-Jun-16	225	89.0	65.4	10.7	38.5	73.5	Right	M
26-Jun-16	200	86.0	60.9	10.0	33.9	63.5	Right	M
26-Jun-16	75	66.7	47.9	9.1	30.8	39.0	Right	M
26-Jun-16	250	88.6	66.8	12.1	37.9	79.8	Left	M
26-Jun-16	220	85.1	62.3	8.9	34.2	66.9	Left	M
26-Jun-16	175	80.4	58.8	9.8	32.7	58.8	Left	M
26-Jun-16	125	77.7	57.5	10.2	34.3	47.3	Unknown	NF
29-Jun-16	160	78.3	58.9	11.6	31.7	61.1	Left	M
29-Jun-16	350	89.8	65.2	12.2	37.1	82.9	Right	M
29-Jun-16	245	92.2	66.7	11.8	37.2	73.8	Left	M
29-Jun-16	145	75.1	57	10.3	29.5	63.7	Left	M
29-Jun-16	150	79.2	58.6	8.1	35.7	50.6	Right	NF
29-Jun-16	75	58.4	48.4	10.3	30.8	39.3	Unknown	NF
29-Jun-16	125	74.8	55.2	8.4	32.7	46.7	Unknown	NF
29-Jun-16	125	72.3	55.3	8.9	33	44.7	Unknown	NF
30-Jun-16	40	48.3	37.4	6.7	21.7	21.2	Unknown	M
30-Jun-16	185	80.3	59.3	11.7	32.9	62	Left	M
30-Jun-16	145	72.9	57.6	10.2	32.9	59	Unknown	M
30-Jun-16	150	76.2	56.1	12.5	32.1	58.9	Left	M
30-Jun-16	150	76.2	56.7	10.9	32.1	44.7	Unknown	NF
30-Jun-16	145	72.1	54.8	11.5	34.9	45.3	Left	NF
30-Jun-16	45	56.5	43.9	8.6	24.9	29.2	Unknown	NF
30-Jun-16	150	74.4	56.3	9.4	35.7	49.0	Right	NF
30-Jun-16	90	60.9	50.2	12.1	31.3	42.9	Unknown	NF
2-Jul-16	160	78.0	58.8	10.4	35.3	54.3	Right	M
2-Jul-16	220	84.2	60.3	12.3	36.3	78.7	Right	M
2-Jul-16	110	74.2	55.7	10.2	33.6	42.9	Unknown	OF
2-Jul-16	120	69.8	52.3	8.6	29.0	38.5	Right	OF
2-Jul-16	150	84.0	59.6	10.2	32.4	49.4	Unknown	OF
2-Jul-16	120	74.4	60.3	8.8	31.4	44.1	Unknown	OF
2-Jul-16	190	89.6	70.6	8.6	36.1	48.0	Right	OF
2-Jul-16	145	73.8	59.7	9.1	31.8	47.7	Left	OF
2-Jul-16	150	77.9	59.5	8.8	34.5	49.1	Unknown	OF
2-Jul-16	175	83.8	63.2	12.3	36.2	46.6	Right	OF
7-Jul-16	200	84.1	63.2	10.3	32.9	62.0	Right	M

Appendix A2 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
7-Jul-16	150	80.0	65.5	10.7	31.3	53.6	Right	M
7-Jul-16	175	79.9	59.7	11.5	36.0	60.6	Left	M
7-Jul-16	200	80.7	62.6	9.7	33.4	48.6	Right	NF
7-Jul-16	200	85.6	61.0	10.7	36.2	50.5	Right	NF
7-Jul-16	150	75.6	62.8	13.2	32.6	42.3	Unknown	NF
7-Jul-16	145	72.6	58.6	10.3	31.9	42.8	Unknown	NF
7-Jul-16	155	82.2	60.2	11.4	31.7	44.9	Left	OF
7-Jul-16	110	65.6	53.4	7.9	27.3	40.7	Unknown	OF
7-Jul-16	125	76.0	55.2	10.4	30.1	39.1	Unknown	OF
9-Jul-16	190	83.2	59.2	10.4	33.9	70.8	Right	M
9-Jul-16	160	75.9	62.3	8.8	29.0	65.8	Right	M
9-Jul-16	150	73.6	58.8	10.1	34.7	58.7	Right	M
9-Jul-16	210	78.7	62.7	8.9	36.3	65.2	Unknown	M
9-Jul-16	175	83.4	62.1	10.3	34.6	62.7	Unknown	M
9-Jul-16	250	94.0	69.1	12.8	37.8	70.0	Right	M
9-Jul-16	190	80.2	61.9	10.6	34.1	71.9	Right	M
9-Jul-16	225	78.3	67.6	11.1	33.8	77.8	Left	M
9-Jul-16	200	80.4	62.5	10.9	34.1	56.6	Left	M
9-Jul-16	175	77.7	59.2	11.0	33.0	69.7	Left	M
12-Jul-16	200	78.9	62.8	7.0	31.0	73.3	Right	M
12-Jul-16	150	75.0	55.8	7.9	32.3	57.9	Unknown	M
12-Jul-16	175	77.7	58.5	8.5	33.9	54.2	Right	M
12-Jul-16	140	73.3	47.8	9.2	33.4	54.3	Right	M
12-Jul-16	200	80.1	62.9	9.8	35.2	66.5	Right	M
12-Jul-16	50	45.4	36.1	5.2	21.6	25.5	Right	M
12-Jul-16	180	62.8	65.7	10.2	34.2	65.6	Right	M
12-Jul-16	150	77.8	56.6	11.0	31.8	52.9	Unknown	M
12-Jul-16	225	80.1	64.4	9.3	31.4	73.4	Left	M
12-Jul-16	250	88.9	67.4	10.1	32.4	73.5	Right	M
15-Jul-16	300	87.8	63.8	12.8	29.4	71.4	Left	M
15-Jul-16	250	88.7	66.5	10.5	37.0	74.3	Left	M
15-Jul-16	175	79.4	60.7	11.0	36.7	64.6	Right	M
15-Jul-16	200	87.6	63.6	11.2	36.1	81.9	Left	M
15-Jul-16	380	80.9	61.5	10.5	34.2	66.7	Right	M
15-Jul-16	175	80.2	59.8	9.0	34.2	62.1	Left	M
15-Jul-16	210	87.9	61.4	10.4	31.9	66.4	Left	M
15-Jul-16	210	80.7	62.8	9.4	34.1	69.7	Right	M
15-Jul-16	300	93.4	74.6	10.5	34.7	77.9	Right	M
15-Jul-16	300	83.3	62.9	9.2	34.7	68.3	Right	M
19-Jul-16	150	76.2	57.9	11.4	33.8	54.7	Left	M
19-Jul-16	400	91.5	70.0	12.8	34.4	83.9	Right	M
19-Jul-16	150	74.6	52.9	9.6	30.3	56.0	Right	M
19-Jul-16	255	90.6	65.5	10.9	35.1	75.0	Left	M

Appendix A2 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
19-Jul-16	210	87.0	64.4	10.9	37.7	67.3	Right	M
19-Jul-16	175	80.0	60.4	10.2	32.0	61.2	Right	M
19-Jul-16	150	73.8	55.1	9.7	33.6	54.3	Left	M
19-Jul-16	175	82.4	59.2	9.5	33.0	77.6	Right	M
19-Jul-16	175	81.7	61.0	11.0	34.7	62.0	Right	M
19-Jul-16	130	70.5	56.6	10.2	31.0	44.3	Right	NF
21-Jul-16	300	83.7	62.6	9.6	31.9	68.1	Right	M
21-Jul-16	175	82.4	61.7	10.0	31.4	58.5	Unknown	M
21-Jul-16	220	84.4	65.4	9.6	35.9	66.1	Left	M
21-Jul-16	190	82.3	60.4	11.0	31.4	64.4	Right	M
21-Jul-16	400	87.8	65.9	15.3	38.7	69.0	Left	M
21-Jul-16	175	86.8	64.1	11.6	35.2	63.1	Left	M
21-Jul-16	125	77.6	55.2	9.3	31.8	54.5	Unknown	M
21-Jul-16	200	81.6	62.6	9.7	34.3	67.5	Right	M
21-Jul-16	150	76.8	57.6	11.1	33.1	53.9	Unknown	M
21-Jul-16	225	82.5	65.9	10.7	35.9	67.3	Right	M
24-Jul-16	250	86.6	69.7	10.3	37.7	73.3	Left	M
24-Jul-16	125	69.0	51.9	6.0	29.2	49.4	Unknown	M
24-Jul-16	150	77.2	61.7	6.4	32.2	58.3	Right	M
24-Jul-16	210	84.2	62.2	10.9	35.0	75.4	Left	M
24-Jul-16	190	76.8	58.4	9.5	33.5	62.1	Right	M
24-Jul-16	120	67.6	53.7	10.5	29.4	46.5	Unknown	M
24-Jul-16	175	80.4	57.8	9.3	32.4	66.2	Left	M
24-Jul-16	150	74.4	54.4	9.5	31.6	46.7	Left	NF
24-Jul-16	150	81.2	58.3	8.8	31.6	48.3	Right	OF
24-Jul-16	150	76.3	59.5	9.2	33.6	47.5	Right	OF
26-Jul-16	200	86.3	63.1	8.2	33.4	71.0	Right	M
26-Jul-16	150	73.8	54.6	7.2	30.5	45.7	Unknown	OF
26-Jul-16	100	68.6	52.8	7.0	27.7	40.4	Unknown	OF
26-Jul-16	150	72.8	58.9	8.9	30.8	40.2	Unknown	OF
26-Jul-16	175	84.5	64.8	11.1	35.6	55.6	Right	OF
26-Jul-16	100	72.5	54.9	10.6	28.5	42.0	Left	OF
26-Jul-16	150	75.9	54.4	8.1	29.6	45.0	Unknown	OF
26-Jul-16	75	81.5	62.8	8.3	29.4	48.7	Unknown	OF
26-Jul-16	100	68.1	49.7	9.2	28.7	36.0	Unknown	OF
26-Jul-16	145	74.9	55.5	9.3	32.4	42.6	Right	OF
28-Jul-16	50	53.6	41.8	7.2	23.8	29.2	Unknown	M
28-Jul-16	200	84.6	61.9	10.5	35.2	63.3	Right	M
28-Jul-16	175	75.8	57.4	7.4	32.1	68.3	Left	M
28-Jul-16	100	61.4	47.3	9.2	29.3	39.1	Unknown	M
28-Jul-16	150	78.9	53.4	9.1	30.8	60.7	Left	M
28-Jul-16	150	74.3	56.0	8.6	29.1	66.5	Right	M
28-Jul-16	240	85.4	63.5	10.6	32.8	77.4	Unknown	M

Appendix A2 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3).

Date	Mass	CW	CL	IO	FO	Chela	Side	Sex
28-Jul-16	200	83.5	60	12.2	32.1	65.5	Unknown	M
28-Jul-16	100	64.9	52.1	9.2	30.1	37.8	Unknown	NF
28-Jul-16	125	72.3	54.9	10	31.6	38	Left	OF
30-Jul-16	220	84.6	63.8	11.5	36.6	78.3	Right	M
30-Jul-16	160	79.0	59.4	10.6	35.3	62.3	Right	M
30-Jul-16	110	70.5	54.0	8.5	29.0	42.9	Unknown	NF
30-Jul-16	150	75.2	56.7	9.2	32.4	47.5	Unknown	NF
30-Jul-16	150	78.8	61.5	9.4	33.5	53.2	Right	NF
30-Jul-16	100	70.0	53.5	8.9	29.9	38.4	Unknown	NF
30-Jul-16	150	81.1	61.0	10.8	33.4	51.2	Unknown	NF
30-Jul-16	150	79.4	57.7	11.7	29.0	47.1	Unknown	NF
30-Jul-16	90	69.2	54.8	8.1	30.4	43.3	Left	NF
30-Jul-16	125	76.7	57.8	9.9	33.1	42.8	Right	NF
2-Aug-16	150	70.3	52.4	9.6	29.8	57.6	Left	M
2-Aug-16	260	89.9	62.9	8.7	36.7	83.6	Right	M
2-Aug-16	160	77.9	61.4	8.4	32.1	46.4	Unknown	NF
2-Aug-16	150	77.1	57.5	9.0	32.8	41.1	Unknown	NF
2-Aug-16	150	68.5	52.1	9.9	31.4	44.4	Unknown	NF
2-Aug-16	125	71.6	56.4	8.4	31.0	41.2	Unknown	NF
2-Aug-16	125	70.5	56.2	9.4	32.6	29.3	Unknown	NF
2-Aug-16	125	74.3	54.6	9.2	30.3	44.5	Unknown	NF
2-Aug-16	140	74.7	53.3	8.4	33.4	48.6	Unknown	NF
2-Aug-16	190	78.0	59.9	9.0	32.7	47.0	Unknown	NF
3-Aug-16	225	83.8	63.3	9.4	32.0	74.0	Right	M
3-Aug-16	200	84.2	61.3	9.6	33.4	70.5	Left	M
3-Aug-16	60	60.4	46.4	8.3	26.9	26.6	Left	NF
3-Aug-16	150	78.3	58.7	9.8	32.0	45.5	Unknown	NF
3-Aug-16	150	77.7	58.5	10.3	31.9	43.6	Unknown	NF
3-Aug-16	145	77.2	57.5	8.3	31.8	40.9	Unknown	NF
3-Aug-16	150	80.2	59.5	8.2	32.8	47.7	Left	NF
3-Aug-16	100	69.3	54.1	9.8	31.4	38.3	Unknown	NF
3-Aug-16	200	82.9	65.7	10.5	35.7	52.2	Left	NF
3-Aug-16	145	76.0	58.3	10.1	33.7	47.3	Unknown	NF
5-Aug-16	175	80.4	60.3	9.1	31.7	69.1	Left	M
5-Aug-16	210	82.3	60.3	9.7	34.9	69.4	Right	M
5-Aug-16	200	84.1	60.1	9.4	31.8	67.2	Right	M
5-Aug-16	200	82.1	62.1	9.7	35.5	70.7	Right	M
5-Aug-16	150	75.6	58.2	8.9	32.7	49.0	Unknown	NF
5-Aug-16	150	76.8	56.2	9.9	31.5	45.3	Left	NF
5-Aug-16	150	76.0	59.8	8.7	33.0	48.7	Left	NF
5-Aug-16	150	79.3	59.1	9.0	31.2	47.2	Unknown	NF
5-Aug-16	150	76.4	58.1	9.6	32.3	42.3	Unknown	NF
5-Aug-16	150	75.4	56.8	9.0	31.2	42.7	Unknown	NF

Appendix A3. Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4). CW indicates carapace width (mm) and RS refers to which road section (1-40) along Queen's Highway, Grand Cayman the individual was encountered. For sex, M indicates male, NF is non-ovigerous female, OF represents ovigerous female, and I refers to an immature (<10mm CW) individual (n=1761).

Date	CW	RS	Sex	Date	CW	RS	Sex
22-May-17	68.3	14	M	23-Jun-17	72.3	12	NF
22-May-17	69.1	11	M	23-Jun-17	72.5	23	NF
22-May-17	69.2	18	M	23-Jun-17	72.7	14	NF
22-May-17	70.0	13	M	23-Jun-17	73.0	15	NF
22-May-17	70.1	13	M	23-Jun-17	73.3	16	NF
22-May-17	70.7	9	M	23-Jun-17	73.3	15	NF
22-May-17	71.4	18	M	23-Jun-17	73.3	14	NF
22-May-17	72.8	11	M	23-Jun-17	73.7	11	NF
22-May-17	74.4	14	M	23-Jun-17	74.3	11	NF
22-May-17	74.4	11	M	23-Jun-17	74.5	9	NF
22-May-17	74.8	13	M	23-Jun-17	74.6	18	NF
22-May-17	75.0	13	M	23-Jun-17	74.7	22	NF
22-May-17	75.2	20	M	23-Jun-17	74.9	11	NF
22-May-17	75.7	2	M	23-Jun-17	75.0	13	NF
22-May-17	79.0	35	M	23-Jun-17	75.7	15	NF
22-May-17	80.4	35	M	23-Jun-17	76.2	11	NF
22-May-17	82.0	27	M	23-Jun-17	76.3	21	NF
22-May-17	82.5	13	M	23-Jun-17	76.4	19	NF
22-May-17	82.5	22	M	23-Jun-17	76.5	18	NF
22-May-17	83.0	25	M	23-Jun-17	76.5	18	NF
22-May-17	83.3	11	M	23-Jun-17	76.6	15	NF
22-May-17	83.5	19	M	23-Jun-17	76.7	9	NF
22-May-17	83.6	16	M	23-Jun-17	77.5	22	NF
22-May-17	84.2	16	M	23-Jun-17	77.6	14	NF
22-May-17	85.0	14	M	23-Jun-17	77.8	15	NF
22-May-17	87.2	25	M	23-Jun-17	77.8	14	NF
22-May-17	88.3	36	M	23-Jun-17	78.1	18	NF
22-May-17	88.6	22	M	23-Jun-17	78.2	14	NF
22-May-17	90.4	18	M	23-Jun-17	78.3	22	NF
23-May-17	53.5	34	M	23-Jun-17	78.3	10	NF
23-May-17	73.0	22	M	23-Jun-17	79.0	32	NF
23-May-17	77.5	19	M	23-Jun-17	79.2	14	NF
23-May-17	79.4	11	M	23-Jun-17	79.4	13	NF
23-May-17	79.5	10	M	23-Jun-17	79.6	18	NF
23-May-17	79.6	21	M	23-Jun-17	80.6	22	NF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
23-May-17	82.2	14	M	23-Jun-17	81.5	16	NF
23-May-17	84.0	38	M	23-Jun-17	82.5	18	NF
23-May-17	90.7	36	M	23-Jun-17	83.2	12	NF
23-May-17	90.8	18	M	23-Jun-17	83.7	13	NF
23-May-17	91.3	22	M	23-Jun-17	84.2	19	NF
23-May-17	56.0	35	NF	23-Jun-17	85.3	16	NF
23-May-17	78.1	9	NF	23-Jun-17	67.6	21	OF
24-May-17	73.1	12	M	23-Jun-17	68.3	23	OF
24-May-17	74.3	11	M	23-Jun-17	68.9	19	OF
24-May-17	77.5	5	M	23-Jun-17	70.9	24	OF
24-May-17	79.2	11	M	23-Jun-17	73.3	4	OF
24-May-17	81.8	15	M	23-Jun-17	73.8	16	OF
24-May-17	82.2	11	M	23-Jun-17	75.6	18	OF
24-May-17	83.2	37	M	23-Jun-17	75.9	24	OF
24-May-17	83.8	5	M	23-Jun-17	79.3	30	OF
24-May-17	84.2	40	M	23-Jun-17	80.4	19	OF
24-May-17	85.7	24	M	23-Jun-17	84.9	21	OF
24-May-17	88.5	5	M	24-Jun-17	71.5	18	M
24-May-17	69.4	12	NF	24-Jun-17	71.9	18	M
24-May-17	74.2	28	NF	24-Jun-17	76.1	14	M
24-May-17	78.2	12	NF	24-Jun-17	77.9	18	M
24-May-17	79.9	30	NF	24-Jun-17	78.8	12	M
24-May-17	82.3	12	NF	24-Jun-17	78.8	12	M
25-May-17	68.6	18	M	24-Jun-17	79.3	12	M
25-May-17	71.9	11	M	24-Jun-17	80.4	18	M
25-May-17	74.3	34	M	24-Jun-17	81.3	22	M
25-May-17	79.0	39	M	24-Jun-17	81.6	11	M
25-May-17	79.8	15	M	24-Jun-17	83.3	14	M
25-May-17	80.1	20	M	24-Jun-17	84.0	12	M
25-May-17	81.4	15	M	24-Jun-17	7.8	18	I
25-May-17	82.6	24	M	24-Jun-17	45.5	15	NF
25-May-17	83.6	16	M	24-Jun-17	61.9	15	NF
25-May-17	83.7	30	M	24-Jun-17	65.8	14	NF
25-May-17	83.8	11	M	24-Jun-17	68.3	10	NF
25-May-17	84.3	6	M	24-Jun-17	68.8	12	NF
25-May-17	84.8	15	M	24-Jun-17	71.9	19	NF
25-May-17	87.9	12	M	24-Jun-17	72.4	11	NF
25-May-17	88.7	16	M	24-Jun-17	73.5	18	NF
25-May-17	89.7	15	M	24-Jun-17	74.5	22	NF
25-May-17	90.3	8	M	24-Jun-17	74.9	16	NF
25-May-17	70.9	15	NF	24-Jun-17	75.4	19	NF
25-May-17	71.7	16	NF	24-Jun-17	76.8	22	NF
25-May-17	74.0	16	NF	24-Jun-17	78.7	19	NF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
25-May-17	74.9	13	NF	24-Jun-17	79.5	11	NF
25-May-17	75.6	16	NF	24-Jun-17	81.1	6	NF
25-May-17	76.3	15	NF	24-Jun-17	81.9	19	NF
25-May-17	76.3	16	NF	24-Jun-17	82.1	11	NF
25-May-17	78.3	16	NF	24-Jun-17	84.3	19	NF
25-May-17	82.1	14	NF	24-Jun-17	84.5	17	NF
25-May-17	84.7	16	NF	24-Jun-17	84.7	17	NF
26-May-17	78.0	12	M	24-Jun-17	65.9	18	OF
26-May-17	80.5	33	M	24-Jun-17	69.4	21	OF
26-May-17	81.1	12	M	24-Jun-17	70.4	22	OF
26-May-17	81.6	18	M	24-Jun-17	71.9	22	OF
26-May-17	82.2	12	M	24-Jun-17	72.8	21	OF
26-May-17	82.3	12	M	24-Jun-17	72.9	18	OF
26-May-17	84.8	12	M	24-Jun-17	73.1	11	OF
26-May-17	85.7	18	M	24-Jun-17	74.2	6	OF
26-May-17	87.8	12	M	24-Jun-17	74.5	18	OF
26-May-17	87.8	12	M	24-Jun-17	75.8	19	OF
26-May-17	87.9	12	M	24-Jun-17	77.9	19	OF
26-May-17	89.7	12	M	24-Jun-17	78.7	19	OF
26-May-17	91.2	12	M	26-Jun-17	73.9	18	M
26-May-17	96.5	12	M	26-Jun-17	75.0	21	M
26-May-17	69.7	11	NF	26-Jun-17	78.9	23	M
26-May-17	70.3	33	NF	26-Jun-17	79.8	16	M
26-May-17	78.0	12	NF	26-Jun-17	81.9	19	M
26-May-17	78.1	12	NF	26-Jun-17	82.0	20	M
26-May-17	81.4	12	NF	26-Jun-17	82.6	11	M
26-May-17	81.8	12	NF	26-Jun-17	83.1	17	M
27-May-17	74.1	12	M	26-Jun-17	87.2	21	M
27-May-17	80.3	12	M	26-Jun-17	65.7	3	NF
27-May-17	83.1	31	M	26-Jun-17	68.2	9	NF
27-May-17	84.2	12	M	26-Jun-17	80.0	32	NF
27-May-17	84.4	30	M	26-Jun-17	83.8	28	NF
27-May-17	67.0	12	NF	26-Jun-17	71.2	29	OF
27-May-17	72.2	14	NF	26-Jun-17	84.8	11	OF
28-May-17	69.1	11	NF	27-Jun-17	10.7	17	M
28-May-17	71.2	11	NF	27-Jun-17	73.2	20	M
28-May-17	78.4	14	NF	27-Jun-17	73.6	16	M
29-May-17	72.9	23	M	27-Jun-17	76.8	34	M
31-May-17	71.1	14	M	27-Jun-17	80.5	18	M
31-May-17	71.8	21	M	27-Jun-17	81.6	18	M
31-May-17	72.7	11	M	27-Jun-17	82.5	17	M
31-May-17	74.4	15	M	27-Jun-17	83.6	20	M
31-May-17	74.6	16	M	27-Jun-17	85.9	22	M

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex
31-May-17	78.3	19	M
31-May-17	79.4	16	M
31-May-17	79.5	14	M
31-May-17	80.9	16	M
31-May-17	80.9	17	M
31-May-17	83.8	3	M
31-May-17	86.8	20	M
31-May-17	87.9	31	M
31-May-17	88.6	16	M
31-May-17	22.8	16	NF
31-May-17	74.1	18	NF
31-May-17	82.7	22	NF
31-May-17	82.8	24	NF
31-May-17	88.0	22	NF
1-Jun-17	77.3	12	M
1-Jun-17	86.0	14	M
1-Jun-17	87.0	11	M
1-Jun-17	90.1	20	M
2-Jun-17	77.9	16	M
4-Jun-17	76.7	13	M
4-Jun-17	87.6	30	M
5-Jun-17	10.8	27	M
5-Jun-17	12.0	6	M
5-Jun-17	12.1	7	M
5-Jun-17	14.1	2	M
5-Jun-17	16.0	11	M
5-Jun-17	17.1	4	M
5-Jun-17	20.1	9	M
5-Jun-17	69.9	27	M
5-Jun-17	77.7	13	M
5-Jun-17	84.5	13	M
5-Jun-17	85.2	13	M
5-Jun-17	88.3	30	M
5-Jun-17	6.0	21	I
5-Jun-17	16.2	26	NF
5-Jun-17	73.4	20	NF
5-Jun-17	76.4	26	NF
6-Jun-17	10.6	34	M
6-Jun-17	14.6	5	M
6-Jun-17	73.7	9	M
6-Jun-17	85.9	5	M
6-Jun-17	87.6	7	M
6-Jun-17	7.6	32	I
27-Jun-17	75.1	28	NF
27-Jun-17	67.6	12	OF
27-Jun-17	83.2	21	OF
28-Jun-17	17.8	2	M
28-Jun-17	71.2	25	M
28-Jun-17	74.2	20	M
28-Jun-17	74.5	20	M
28-Jun-17	76.7	14	M
28-Jun-17	79.1	14	M
28-Jun-17	79.5	21	M
28-Jun-17	79.7	17	M
28-Jun-17	80.1	25	M
28-Jun-17	80.3	13	M
28-Jun-17	80.7	17	M
28-Jun-17	81.1	20	M
28-Jun-17	81.1	17	M
28-Jun-17	82.1	23	M
28-Jun-17	86.4	23	M
28-Jun-17	91.8	24	M
28-Jun-17	18.5	4	NF
28-Jun-17	62.1	30	NF
28-Jun-17	63.0	19	NF
28-Jun-17	69.4	12	NF
28-Jun-17	71.5	5	NF
28-Jun-17	73.6	18	NF
28-Jun-17	74.8	18	NF
28-Jun-17	75.1	14	NF
28-Jun-17	76.3	19	NF
28-Jun-17	81.2	20	NF
28-Jun-17	68.9	20	OF
28-Jun-17	71.2	19	OF
29-Jun-17	74.1	40	M
29-Jun-17	88.7	22	M
29-Jun-17	9.6	18	I
29-Jun-17	66.8	23	NF
29-Jun-17	69.3	23	NF
29-Jun-17	72.8	21	NF
29-Jun-17	74.1	3	NF
29-Jun-17	75.1	17	NF
29-Jun-17	75.7	18	NF
30-Jun-17	76.9	6	NF
2-Jul-17	22.0	13	M
2-Jul-17	73.0	12	M

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
6-Jun-17	8.6	32	I	2-Jul-17	73.9	18	M
6-Jun-17	12.6	26	NF	2-Jul-17	77.3	13	M
6-Jun-17	8.9	26	I	2-Jul-17	77.8	13	M
9-Jun-17	10.3	25	M	2-Jul-17	80.8	18	M
10-Jun-17	12.4	25	M	2-Jul-17	83.9	12	M
11-Jun-17	78.8	20	M	2-Jul-17	86.1	15	M
11-Jun-17	69.6	30	NF	2-Jul-17	73.9	15	NF
13-Jun-17	64.0	25	OF	2-Jul-17	77.9	12	NF
14-Jun-17	79.4	20	OF	3-Jul-17	14.6	21	M
15-Jun-17	79.4	23	M	3-Jul-17	82.4	13	M
15-Jun-17	63.8	12	OF	3-Jul-17	82.8	17	M
15-Jun-17	72.2	2	OF	5-Jul-17	88.1	12	M
15-Jun-17	77.7	15	OF	5-Jul-17	77.8	17	NF
15-Jun-17	81.4	10	OF	6-Jul-17	84.5	23	M
15-Jun-17	84.3	12	OF	6-Jul-17	71.8	33	OF
15-Jun-17	87.0	12	OF	7-Jul-17	80.5	12	M
16-Jun-17	14.7	31	M	7-Jul-17	69.9	3	OF
16-Jun-17	74.3	20	M	7-Jul-17	70.1	1	OF
16-Jun-17	76.1	14	M	8-Jul-17	79.6	12	M
16-Jun-17	77.1	16	M	8-Jul-17	91.5	13	M
16-Jun-17	77.6	15	M	8-Jul-17	58.7	14	OF
16-Jun-17	77.7	20	M	8-Jul-17	67.3	15	OF
16-Jun-17	79.6	17	M	8-Jul-17	67.3	12	OF
16-Jun-17	79.7	14	M	8-Jul-17	73.0	12	OF
16-Jun-17	80.2	19	M	8-Jul-17	73.4	12	OF
16-Jun-17	81.9	19	M	8-Jul-17	74.8	16	OF
16-Jun-17	82.8	18	M	8-Jul-17	77.3	12	OF
16-Jun-17	83.7	16	M	8-Jul-17	80.5	11	OF
16-Jun-17	84.1	6	M	8-Jul-17	81.4	13	OF
16-Jun-17	84.2	17	M	9-Jul-17	67.7	18	OF
16-Jun-17	84.3	15	M	9-Jul-17	70.9	22	OF
16-Jun-17	84.4	14	M	9-Jul-17	72.9	15	OF
16-Jun-17	84.7	17	M	9-Jul-17	74.6	13	OF
16-Jun-17	84.7	20	M	9-Jul-17	75.2	22	OF
16-Jun-17	84.8	17	M	10-Jul-17	81.6	8	M
16-Jun-17	85.1	19	M	10-Jul-17	84.2	18	M
16-Jun-17	88.1	14	M	10-Jul-17	87.9	20	M
16-Jun-17	89.1	21	M	10-Jul-17	73.5	21	NF
16-Jun-17	89.2	18	M	10-Jul-17	76.5	2	NF
16-Jun-17	8.2	18	I	10-Jul-17	66.8	14	OF
16-Jun-17	9.9	16	I	10-Jul-17	70.3	10	OF
16-Jun-17	18.3	18	NF	10-Jul-17	73.5	15	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
16-Jun-17	45.0	30	NF	10-Jul-17	74.4	12	OF
16-Jun-17	70.2	30	NF	10-Jul-17	75.2	31	OF
16-Jun-17	71.9	19	NF	10-Jul-17	75.9	12	OF
16-Jun-17	75.7	14	NF	10-Jul-17	76.8	9	OF
16-Jun-17	76.7	16	NF	10-Jul-17	78.8	11	OF
16-Jun-17	77.6	14	NF	10-Jul-17	80.7	15	OF
16-Jun-17	78.6	17	NF	10-Jul-17	83.5	17	OF
16-Jun-17	79.4	17	NF	11-Jul-17	79.2	14	M
16-Jun-17	79.7	17	NF	11-Jul-17	80.0	10	M
16-Jun-17	87.7	17	NF	11-Jul-17	80.5	24	M
16-Jun-17	63.2	2	OF	11-Jul-17	86.5	17	M
16-Jun-17	69.5	14	OF	11-Jul-17	96.0	14	M
16-Jun-17	72.1	11	OF	11-Jul-17	58.9	17	NF
16-Jun-17	72.2	9	OF	11-Jul-17	60.4	13	NF
16-Jun-17	72.8	12	OF	11-Jul-17	68.2	11	NF
16-Jun-17	76.6	16	OF	11-Jul-17	68.9	21	NF
16-Jun-17	77.7	18	OF	11-Jul-17	70.2	20	NF
16-Jun-17	78.3	15	OF	11-Jul-17	71.5	11	NF
16-Jun-17	80.1	6	OF	11-Jul-17	72.6	17	NF
16-Jun-17	80.3	9	OF	11-Jul-17	72.9	18	NF
18-Jun-17	10.0	28	M	11-Jul-17	73.5	11	NF
18-Jun-17	10.3	25	M	11-Jul-17	74.1	19	NF
18-Jun-17	10.4	19	M	11-Jul-17	75.0	15	NF
18-Jun-17	10.5	19	M	11-Jul-17	76.1	17	NF
18-Jun-17	10.5	16	M	11-Jul-17	76.6	20	NF
18-Jun-17	10.6	24	M	11-Jul-17	78.7	12	NF
18-Jun-17	10.7	15	M	11-Jul-17	79.4	17	NF
18-Jun-17	11.6	27	M	11-Jul-17	80.4	13	NF
18-Jun-17	11.9	33	M	11-Jul-17	83.2	16	NF
18-Jun-17	12.2	11	M	11-Jul-17	83.4	18	NF
18-Jun-17	12.4	24	M	13-Jul-17	78.1	16	M
18-Jun-17	12.8	1	M	13-Jul-17	79.2	2	M
18-Jun-17	13.5	24	M	13-Jul-17	82.5	12	M
18-Jun-17	14.2	29	M	13-Jul-17	61.6	15	NF
18-Jun-17	15.1	25	M	13-Jul-17	73.2	12	NF
18-Jun-17	15.1	21	M	13-Jul-17	71.7	12	OF
18-Jun-17	16.2	9	M	13-Jul-17	73.8	33	OF
18-Jun-17	20.2	1	M	13-Jul-17	74.9	12	OF
18-Jun-17	30.0	32	M	13-Jul-17	80.0	33	OF
18-Jun-17	63.8	31	M	16-Jul-17	80.6	19	M
18-Jun-17	63.9	29	M	16-Jul-17	82.5	13	M
18-Jun-17	64.7	13	M	16-Jul-17	82.9	11	M
18-Jun-17	64.8	30	M	16-Jul-17	85.4	13	M

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
18-Jun-17	65.9	17	M	16-Jul-17	72.5	9	NF
18-Jun-17	67.8	32	M	16-Jul-17	54.6	2	OF
18-Jun-17	70.0	16	M	16-Jul-17	58.7	22	OF
18-Jun-17	70.2	12	M	16-Jul-17	59.0	22	OF
18-Jun-17	71.2	13	M	16-Jul-17	60.6	20	OF
18-Jun-17	71.7	14	M	16-Jul-17	61.9	22	OF
18-Jun-17	71.9	24	M	16-Jul-17	62.8	13	OF
18-Jun-17	72.4	16	M	16-Jul-17	63.4	21	OF
18-Jun-17	73.4	2	M	16-Jul-17	63.5	22	OF
18-Jun-17	73.9	29	M	16-Jul-17	64.1	21	OF
18-Jun-17	74.3	30	M	16-Jul-17	64.4	20	OF
18-Jun-17	75.0	16	M	16-Jul-17	64.5	20	OF
18-Jun-17	75.0	15	M	16-Jul-17	65.4	20	OF
18-Jun-17	75.0	15	M	16-Jul-17	65.5	22	OF
18-Jun-17	75.0	14	M	16-Jul-17	66.1	23	OF
18-Jun-17	75.0	13	M	16-Jul-17	66.4	18	OF
18-Jun-17	75.0	10	M	16-Jul-17	66.4	8	OF
18-Jun-17	75.1	19	M	16-Jul-17	66.5	13	OF
18-Jun-17	75.3	30	M	16-Jul-17	66.7	29	OF
18-Jun-17	76.1	2	M	16-Jul-17	67.1	11	OF
18-Jun-17	76.7	21	M	16-Jul-17	67.4	20	OF
18-Jun-17	77.0	17	M	16-Jul-17	67.4	17	OF
18-Jun-17	77.3	13	M	16-Jul-17	67.4	17	OF
18-Jun-17	77.4	19	M	16-Jul-17	67.7	20	OF
18-Jun-17	78.8	16	M	16-Jul-17	68.3	21	OF
18-Jun-17	79.7	17	M	16-Jul-17	68.9	3	OF
18-Jun-17	80.0	16	M	16-Jul-17	69.0	19	OF
18-Jun-17	80.0	15	M	16-Jul-17	69.1	20	OF
18-Jun-17	80.0	14	M	16-Jul-17	69.1	17	OF
18-Jun-17	80.0	13	M	16-Jul-17	69.1	16	OF
18-Jun-17	80.0	10	M	16-Jul-17	69.3	17	OF
18-Jun-17	80.1	11	M	16-Jul-17	69.5	11	OF
18-Jun-17	80.1	4	M	16-Jul-17	69.7	19	OF
18-Jun-17	80.4	16	M	16-Jul-17	70.0	22	OF
18-Jun-17	80.4	14	M	16-Jul-17	70.0	20	OF
18-Jun-17	80.5	15	M	16-Jul-17	70.3	14	OF
18-Jun-17	80.8	4	M	16-Jul-17	70.4	30	OF
18-Jun-17	80.9	11	M	16-Jul-17	70.4	24	OF
18-Jun-17	80.9	3	M	16-Jul-17	70.4	22	OF
18-Jun-17	81.0	30	M	16-Jul-17	70.4	5	OF
18-Jun-17	81.1	12	M	16-Jul-17	70.4	3	OF
18-Jun-17	81.2	35	M	16-Jul-17	70.5	19	OF
18-Jun-17	81.2	15	M	16-Jul-17	70.6	15	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
18-Jun-17	81.2	15	M	16-Jul-17	70.8	13	OF
18-Jun-17	81.2	12	M	16-Jul-17	70.9	22	OF
18-Jun-17	81.2	12	M	16-Jul-17	70.9	13	OF
18-Jun-17	81.2	11	M	16-Jul-17	71.0	14	OF
18-Jun-17	81.3	19	M	16-Jul-17	71.1	22	OF
18-Jun-17	81.3	17	M	16-Jul-17	71.2	11	OF
18-Jun-17	81.7	12	M	16-Jul-17	71.3	16	OF
18-Jun-17	81.8	17	M	16-Jul-17	71.6	17	OF
18-Jun-17	82.0	26	M	16-Jul-17	71.7	22	OF
18-Jun-17	82.1	13	M	16-Jul-17	71.7	15	OF
18-Jun-17	82.2	17	M	16-Jul-17	71.7	14	OF
18-Jun-17	82.4	15	M	16-Jul-17	71.8	11	OF
18-Jun-17	82.4	3	M	16-Jul-17	71.9	21	OF
18-Jun-17	82.5	29	M	16-Jul-17	71.9	19	OF
18-Jun-17	82.6	40	M	16-Jul-17	71.9	15	OF
18-Jun-17	82.7	17	M	16-Jul-17	71.9	15	OF
18-Jun-17	82.8	10	M	16-Jul-17	72.2	13	OF
18-Jun-17	84.4	33	M	16-Jul-17	72.2	12	OF
18-Jun-17	84.7	17	M	16-Jul-17	72.6	17	OF
18-Jun-17	84.9	22	M	16-Jul-17	72.6	14	OF
18-Jun-17	85.0	15	M	16-Jul-17	72.6	13	OF
18-Jun-17	85.0	14	M	16-Jul-17	72.7	17	OF
18-Jun-17	85.0	13	M	16-Jul-17	72.8	17	OF
18-Jun-17	85.2	13	M	16-Jul-17	72.8	14	OF
18-Jun-17	85.2	13	M	16-Jul-17	72.8	13	OF
18-Jun-17	85.2	2	M	16-Jul-17	72.9	12	OF
18-Jun-17	85.8	19	M	16-Jul-17	72.9	12	OF
18-Jun-17	85.8	13	M	16-Jul-17	73.1	31	OF
18-Jun-17	86.3	21	M	16-Jul-17	73.2	19	OF
18-Jun-17	86.6	19	M	16-Jul-17	73.2	19	OF
18-Jun-17	87.6	18	M	16-Jul-17	73.3	20	OF
18-Jun-17	87.7	19	M	16-Jul-17	73.3	14	OF
18-Jun-17	87.8	14	M	16-Jul-17	73.3	14	OF
18-Jun-17	88.3	19	M	16-Jul-17	73.4	15	OF
18-Jun-17	88.5	39	M	16-Jul-17	73.5	19	OF
18-Jun-17	88.7	11	M	16-Jul-17	73.5	15	OF
18-Jun-17	89.2	36	M	16-Jul-17	73.5	12	OF
18-Jun-17	90.8	21	M	16-Jul-17	73.5	9	OF
18-Jun-17	91.2	20	M	16-Jul-17	73.5	7	OF
18-Jun-17	92.5	15	M	16-Jul-17	73.6	19	OF
18-Jun-17	93.2	11	M	16-Jul-17	73.7	17	OF
18-Jun-17	98.7	18	M	16-Jul-17	73.8	19	OF
18-Jun-17	5.0	31	I	16-Jul-17	73.8	16	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
18-Jun-17	5.0	31	I	16-Jul-17	73.8	14	OF
18-Jun-17	5.0	24	I	16-Jul-17	73.9	25	OF
18-Jun-17	5.0	23	I	16-Jul-17	74.1	31	OF
18-Jun-17	5.0	22	I	16-Jul-17	74.1	21	OF
18-Jun-17	6.2	24	I	16-Jul-17	74.2	21	OF
18-Jun-17	6.7	24	I	16-Jul-17	74.2	21	OF
18-Jun-17	6.7	22	I	16-Jul-17	74.2	20	OF
18-Jun-17	7.3	22	I	16-Jul-17	74.3	21	OF
18-Jun-17	7.8	29	I	16-Jul-17	74.4	14	OF
18-Jun-17	8.2	24	I	16-Jul-17	74.4	11	OF
18-Jun-17	8.2	24	I	16-Jul-17	74.5	20	OF
18-Jun-17	8.2	22	I	16-Jul-17	74.5	11	OF
18-Jun-17	8.4	1	I	16-Jul-17	74.7	29	OF
18-Jun-17	8.7	22	I	16-Jul-17	74.8	13	OF
18-Jun-17	9.2	29	I	16-Jul-17	74.8	11	OF
18-Jun-17	9.7	18	I	16-Jul-17	75.0	26	OF
18-Jun-17	13.1	29	NF	16-Jul-17	75.0	20	OF
18-Jun-17	20.6	1	NF	16-Jul-17	75.0	19	OF
18-Jun-17	26.8	16	NF	16-Jul-17	75.1	18	OF
18-Jun-17	26.9	38	NF	16-Jul-17	75.2	14	OF
18-Jun-17	27.8	35	NF	16-Jul-17	75.2	14	OF
18-Jun-17	27.8	5	NF	16-Jul-17	75.3	25	OF
18-Jun-17	29.8	35	NF	16-Jul-17	75.3	19	OF
18-Jun-17	36.2	33	NF	16-Jul-17	75.4	20	OF
18-Jun-17	37.3	16	NF	16-Jul-17	75.4	20	OF
18-Jun-17	45.2	2	NF	16-Jul-17	75.4	17	OF
18-Jun-17	48.5	17	NF	16-Jul-17	75.4	14	OF
18-Jun-17	55.7	17	NF	16-Jul-17	75.5	17	OF
18-Jun-17	59.8	16	NF	16-Jul-17	75.6	19	OF
18-Jun-17	60.0	16	NF	16-Jul-17	75.6	18	OF
18-Jun-17	60.0	16	NF	16-Jul-17	75.7	21	OF
18-Jun-17	63.3	22	NF	16-Jul-17	75.7	14	OF
18-Jun-17	63.5	29	NF	16-Jul-17	75.8	22	OF
18-Jun-17	67.2	11	NF	16-Jul-17	75.8	18	OF
18-Jun-17	69.5	13	NF	16-Jul-17	75.8	14	OF
18-Jun-17	70.2	13	NF	16-Jul-17	75.8	14	OF
18-Jun-17	70.4	12	NF	16-Jul-17	76.0	20	OF
18-Jun-17	70.8	10	NF	16-Jul-17	76.3	19	OF
18-Jun-17	71.0	13	NF	16-Jul-17	76.3	10	OF
18-Jun-17	71.2	10	NF	16-Jul-17	76.5	14	OF
18-Jun-17	71.4	13	NF	16-Jul-17	76.6	20	OF
18-Jun-17	71.9	17	NF	16-Jul-17	76.7	14	OF
18-Jun-17	71.9	14	NF	16-Jul-17	76.8	16	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
18-Jun-17	72.0	17	NF	16-Jul-17	77.0	21	OF
18-Jun-17	72.0	16	NF	16-Jul-17	77.0	12	OF
18-Jun-17	72.4	16	NF	16-Jul-17	77.1	10	OF
18-Jun-17	72.8	14	NF	16-Jul-17	77.5	15	OF
18-Jun-17	72.8	13	NF	16-Jul-17	77.5	14	OF
18-Jun-17	73.1	17	NF	16-Jul-17	77.7	19	OF
18-Jun-17	74.4	19	NF	16-Jul-17	77.7	18	OF
18-Jun-17	74.7	11	NF	16-Jul-17	77.8	9	OF
18-Jun-17	74.9	27	NF	16-Jul-17	78.0	19	OF
18-Jun-17	75.0	19	NF	16-Jul-17	78.1	31	OF
18-Jun-17	75.0	13	NF	16-Jul-17	78.1	16	OF
18-Jun-17	75.0	12	NF	16-Jul-17	78.1	14	OF
18-Jun-17	75.1	11	NF	16-Jul-17	78.2	20	OF
18-Jun-17	75.2	16	NF	16-Jul-17	78.2	20	OF
18-Jun-17	75.5	32	NF	16-Jul-17	78.3	17	OF
18-Jun-17	75.6	11	NF	16-Jul-17	78.4	20	OF
18-Jun-17	75.8	14	NF	16-Jul-17	78.5	18	OF
18-Jun-17	75.8	11	NF	16-Jul-17	78.6	17	OF
18-Jun-17	78.7	4	NF	16-Jul-17	78.6	13	OF
18-Jun-17	80.1	17	NF	16-Jul-17	78.7	11	OF
18-Jun-17	81.2	11	NF	16-Jul-17	78.9	32	OF
18-Jun-17	81.4	16	NF	16-Jul-17	78.9	22	OF
18-Jun-17	6.4	1	I	16-Jul-17	79.0	12	OF
18-Jun-17	6.7	18	I	16-Jul-17	79.1	20	OF
18-Jun-17	9.3	5	I	16-Jul-17	79.2	18	OF
18-Jun-17	9.7	35	I	16-Jul-17	79.3	20	OF
18-Jun-17	21.8	7	OF	16-Jul-17	79.3	19	OF
18-Jun-17	35.8	1	OF	16-Jul-17	79.4	20	OF
18-Jun-17	52.0	20	OF	16-Jul-17	79.4	11	OF
18-Jun-17	52.9	12	OF	16-Jul-17	79.5	19	OF
18-Jun-17	59.7	16	OF	16-Jul-17	79.7	14	OF
18-Jun-17	60.8	11	OF	16-Jul-17	79.8	31	OF
18-Jun-17	62.4	11	OF	16-Jul-17	80.0	19	OF
18-Jun-17	63.1	12	OF	16-Jul-17	80.1	22	OF
18-Jun-17	64.0	19	OF	16-Jul-17	80.2	30	OF
18-Jun-17	64.4	9	OF	16-Jul-17	80.3	20	OF
18-Jun-17	64.9	15	OF	16-Jul-17	80.4	16	OF
18-Jun-17	65.0	16	OF	16-Jul-17	80.4	8	OF
18-Jun-17	65.7	15	OF	16-Jul-17	80.6	16	OF
18-Jun-17	65.8	12	OF	16-Jul-17	80.8	20	OF
18-Jun-17	65.8	10	OF	16-Jul-17	80.8	11	OF
18-Jun-17	65.8	9	OF	16-Jul-17	80.9	9	OF
18-Jun-17	66.5	19	OF	16-Jul-17	81.0	22	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
18-Jun-17	68.1	20	OF	16-Jul-17	81.0	12	OF
18-Jun-17	68.2	6	OF	16-Jul-17	81.0	11	OF
18-Jun-17	68.4	15	OF	16-Jul-17	81.1	19	OF
18-Jun-17	68.4	1	OF	16-Jul-17	81.1	19	OF
18-Jun-17	68.5	18	OF	16-Jul-17	81.2	18	OF
18-Jun-17	68.7	11	OF	16-Jul-17	81.4	19	OF
18-Jun-17	68.9	18	OF	16-Jul-17	81.4	19	OF
18-Jun-17	69.2	25	OF	16-Jul-17	81.6	21	OF
18-Jun-17	69.2	11	OF	16-Jul-17	81.6	14	OF
18-Jun-17	70.0	13	OF	16-Jul-17	81.8	19	OF
18-Jun-17	70.0	12	OF	16-Jul-17	81.8	10	OF
18-Jun-17	70.1	11	OF	16-Jul-17	82.5	13	OF
18-Jun-17	70.4	14	OF	16-Jul-17	83.1	22	OF
18-Jun-17	70.8	9	OF	16-Jul-17	83.1	19	OF
18-Jun-17	70.8	6	OF	16-Jul-17	83.2	22	OF
18-Jun-17	71.1	12	OF	16-Jul-17	83.5	16	OF
18-Jun-17	71.2	15	OF	16-Jul-17	84.1	19	OF
18-Jun-17	71.2	15	OF	16-Jul-17	85.0	12	OF
18-Jun-17	71.2	14	OF	16-Jul-17	86.5	17	OF
18-Jun-17	71.2	10	OF	16-Jul-17	88.8	19	OF
18-Jun-17	71.4	10	OF	16-Jul-17	89.2	22	OF
18-Jun-17	71.6	10	OF	17-Jul-17	51.6	34	M
18-Jun-17	71.6	10	OF	17-Jul-17	75.3	11	M
18-Jun-17	71.8	11	OF	17-Jul-17	75.8	10	M
18-Jun-17	71.9	19	OF	17-Jul-17	78.9	17	M
18-Jun-17	72.3	15	OF	17-Jul-17	79.6	22	M
18-Jun-17	72.5	16	OF	17-Jul-17	79.7	13	M
18-Jun-17	72.7	15	OF	17-Jul-17	79.9	21	M
18-Jun-17	72.8	13	OF	17-Jul-17	80.4	22	M
18-Jun-17	73.4	19	OF	17-Jul-17	80.7	17	M
18-Jun-17	74.2	10	OF	17-Jul-17	80.8	15	M
18-Jun-17	74.6	12	OF	17-Jul-17	82.7	15	M
18-Jun-17	74.7	25	OF	17-Jul-17	82.9	13	M
18-Jun-17	75.0	15	OF	17-Jul-17	84.5	20	M
18-Jun-17	75.0	13	OF	17-Jul-17	85.3	20	M
18-Jun-17	75.0	10	OF	17-Jul-17	85.3	19	M
18-Jun-17	75.2	10	OF	17-Jul-17	86.0	21	M
18-Jun-17	75.5	13	OF	17-Jul-17	86.3	21	M
18-Jun-17	75.6	13	OF	17-Jul-17	87.8	18	M
18-Jun-17	75.6	9	OF	17-Jul-17	89.4	14	M
18-Jun-17	75.8	17	OF	17-Jul-17	92.0	14	M
18-Jun-17	75.8	8	OF	17-Jul-17	93.2	19	M
18-Jun-17	76.3	17	OF	17-Jul-17	95.8	23	M

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
18-Jun-17	77.1	19	OF	17-Jul-17	98.7	21	M
18-Jun-17	77.2	16	OF	17-Jul-17	12.3	13	NF
18-Jun-17	77.6	18	OF	17-Jul-17	13.0	6	NF
18-Jun-17	77.7	19	OF	17-Jul-17	59.5	30	NF
18-Jun-17	77.8	18	OF	17-Jul-17	61.9	2	NF
18-Jun-17	77.8	12	OF	17-Jul-17	63.8	31	NF
18-Jun-17	77.9	20	OF	17-Jul-17	65.5	23	NF
18-Jun-17	78.4	16	OF	17-Jul-17	66.7	19	NF
18-Jun-17	78.4	16	OF	17-Jul-17	67.6	22	NF
18-Jun-17	79.0	17	OF	17-Jul-17	69.0	6	NF
18-Jun-17	79.3	17	OF	17-Jul-17	69.3	13	NF
18-Jun-17	79.4	19	OF	17-Jul-17	70.0	19	NF
18-Jun-17	79.8	13	OF	17-Jul-17	71.4	20	NF
18-Jun-17	80.0	16	OF	17-Jul-17	71.7	20	NF
18-Jun-17	80.0	13	OF	17-Jul-17	72.0	14	NF
18-Jun-17	80.0	12	OF	17-Jul-17	72.9	17	NF
18-Jun-17	80.1	13	OF	17-Jul-17	73.1	17	NF
18-Jun-17	80.1	11	OF	17-Jul-17	74.4	21	NF
18-Jun-17	80.1	11	OF	17-Jul-17	74.6	21	NF
18-Jun-17	80.1	10	OF	17-Jul-17	74.6	20	NF
18-Jun-17	80.4	11	OF	17-Jul-17	75.5	2	NF
18-Jun-17	80.4	9	OF	17-Jul-17	77.7	13	NF
18-Jun-17	80.5	13	OF	17-Jul-17	77.8	28	NF
18-Jun-17	80.7	11	OF	17-Jul-17	77.8	4	NF
18-Jun-17	81.0	16	OF	17-Jul-17	78.0	20	NF
18-Jun-17	81.2	17	OF	17-Jul-17	78.6	13	NF
18-Jun-17	81.2	15	OF	17-Jul-17	78.7	7	NF
18-Jun-17	81.2	13	OF	17-Jul-17	79.7	15	NF
18-Jun-17	81.2	12	OF	17-Jul-17	80.4	17	NF
18-Jun-17	81.2	11	OF	17-Jul-17	84.4	10	NF
18-Jun-17	81.2	10	OF	17-Jul-17	52.3	22	OF
18-Jun-17	81.2	9	OF	17-Jul-17	65.1	8	OF
18-Jun-17	81.4	16	OF	17-Jul-17	65.4	26	OF
18-Jun-17	81.4	10	OF	17-Jul-17	65.7	3	OF
18-Jun-17	82.3	22	OF	17-Jul-17	65.8	21	OF
18-Jun-17	82.4	14	OF	17-Jul-17	66.8	2	OF
18-Jun-17	82.7	9	OF	17-Jul-17	67.4	18	OF
18-Jun-17	83.2	18	OF	17-Jul-17	67.5	23	OF
18-Jun-17	84.4	19	OF	17-Jul-17	67.7	4	OF
18-Jun-17	85.0	16	OF	17-Jul-17	68.3	19	OF
18-Jun-17	85.2	8	OF	17-Jul-17	68.5	19	OF
18-Jun-17	85.7	12	OF	17-Jul-17	68.8	21	OF
18-Jun-17	87.5	17	OF	17-Jul-17	68.8	18	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
19-Jun-17	10.0	20	M	17-Jul-17	68.9	5	OF
19-Jun-17	11.4	31	M	17-Jul-17	69.4	9	OF
19-Jun-17	11.6	9	M	17-Jul-17	69.5	19	OF
19-Jun-17	11.6	8	M	17-Jul-17	69.8	16	OF
19-Jun-17	15.0	10	M	17-Jul-17	70.2	22	OF
19-Jun-17	16.4	24	M	17-Jul-17	70.6	20	OF
19-Jun-17	20.2	20	M	17-Jul-17	70.7	16	OF
19-Jun-17	25.2	15	M	17-Jul-17	70.9	15	OF
19-Jun-17	57.8	21	M	17-Jul-17	71.3	19	OF
19-Jun-17	67.5	18	M	17-Jul-17	71.7	20	OF
19-Jun-17	70.0	12	M	17-Jul-17	72.0	11	OF
19-Jun-17	70.1	18	M	17-Jul-17	72.2	20	OF
19-Jun-17	70.2	20	M	17-Jul-17	72.3	12	OF
19-Jun-17	70.4	21	M	17-Jul-17	72.7	12	OF
19-Jun-17	70.4	20	M	17-Jul-17	72.9	19	OF
19-Jun-17	70.5	20	M	17-Jul-17	72.9	8	OF
19-Jun-17	70.5	17	M	17-Jul-17	73.1	19	OF
19-Jun-17	70.6	16	M	17-Jul-17	73.1	13	OF
19-Jun-17	70.6	15	M	17-Jul-17	73.2	17	OF
19-Jun-17	70.6	12	M	17-Jul-17	73.9	18	OF
19-Jun-17	70.8	7	M	17-Jul-17	74.1	10	OF
19-Jun-17	72.2	30	M	17-Jul-17	74.4	8	OF
19-Jun-17	72.5	19	M	17-Jul-17	74.8	12	OF
19-Jun-17	73.2	23	M	17-Jul-17	75.3	14	OF
19-Jun-17	74.2	29	M	17-Jul-17	75.3	11	OF
19-Jun-17	75.0	21	M	17-Jul-17	75.3	9	OF
19-Jun-17	75.2	17	M	17-Jul-17	75.5	25	OF
19-Jun-17	75.6	24	M	17-Jul-17	75.6	21	OF
19-Jun-17	75.8	17	M	17-Jul-17	75.6	17	OF
19-Jun-17	75.8	10	M	17-Jul-17	75.7	18	OF
19-Jun-17	76.7	24	M	17-Jul-17	75.8	8	OF
19-Jun-17	76.9	19	M	17-Jul-17	76.2	13	OF
19-Jun-17	77.2	19	M	17-Jul-17	76.6	16	OF
19-Jun-17	78.2	16	M	17-Jul-17	76.9	32	OF
19-Jun-17	78.4	35	M	17-Jul-17	77.0	10	OF
19-Jun-17	78.6	17	M	17-Jul-17	77.2	19	OF
19-Jun-17	78.8	18	M	17-Jul-17	77.2	14	OF
19-Jun-17	78.8	11	M	17-Jul-17	77.3	15	OF
19-Jun-17	78.9	27	M	17-Jul-17	77.3	9	OF
19-Jun-17	78.9	14	M	17-Jul-17	77.6	18	OF
19-Jun-17	79.3	36	M	17-Jul-17	78.0	16	OF
19-Jun-17	79.5	28	M	17-Jul-17	78.6	19	OF
19-Jun-17	79.8	22	M	17-Jul-17	78.6	7	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
19-Jun-17	79.8	16	M	17-Jul-17	79.3	18	OF
19-Jun-17	80.1	24	M	17-Jul-17	79.7	12	OF
19-Jun-17	80.1	12	M	17-Jul-17	79.8	21	OF
19-Jun-17	80.1	11	M	17-Jul-17	79.9	10	OF
19-Jun-17	80.2	20	M	17-Jul-17	80.0	19	OF
19-Jun-17	80.2	20	M	17-Jul-17	80.4	25	OF
19-Jun-17	80.2	18	M	17-Jul-17	80.6	16	OF
19-Jun-17	80.2	16	M	17-Jul-17	80.6	10	OF
19-Jun-17	80.2	16	M	17-Jul-17	81.1	10	OF
19-Jun-17	80.5	21	M	17-Jul-17	82.0	14	OF
19-Jun-17	80.5	19	M	17-Jul-17	87.0	14	OF
19-Jun-17	80.5	14	M	18-Jul-17	75.8	14	M
19-Jun-17	80.5	13	M	18-Jul-17	90.9	21	M
19-Jun-17	80.6	21	M	18-Jul-17	92.5	15	M
19-Jun-17	80.6	20	M	18-Jul-17	61.9	23	NF
19-Jun-17	80.7	15	M	18-Jul-17	64.3	31	NF
19-Jun-17	80.8	21	M	18-Jul-17	64.6	30	NF
19-Jun-17	80.8	19	M	18-Jul-17	65.2	13	NF
19-Jun-17	80.8	8	M	18-Jul-17	65.2	11	NF
19-Jun-17	80.8	6	M	18-Jul-17	66.8	17	NF
19-Jun-17	81.0	27	M	18-Jul-17	66.9	12	NF
19-Jun-17	81.2	31	M	18-Jul-17	67.3	20	NF
19-Jun-17	81.6	22	M	18-Jul-17	68.1	18	NF
19-Jun-17	82.1	20	M	18-Jul-17	68.3	17	NF
19-Jun-17	82.4	22	M	18-Jul-17	68.5	13	NF
19-Jun-17	82.7	22	M	18-Jul-17	68.6	16	NF
19-Jun-17	82.7	16	M	18-Jul-17	68.7	24	NF
19-Jun-17	84.5	24	M	18-Jul-17	68.9	21	NF
19-Jun-17	85.2	18	M	18-Jul-17	69.0	17	NF
19-Jun-17	85.2	12	M	18-Jul-17	69.2	17	NF
19-Jun-17	85.6	14	M	18-Jul-17	70.0	17	NF
19-Jun-17	85.7	24	M	18-Jul-17	70.0	17	NF
19-Jun-17	85.7	20	M	18-Jul-17	70.1	16	NF
19-Jun-17	87.7	40	M	18-Jul-17	70.2	14	NF
19-Jun-17	89.1	35	M	18-Jul-17	70.7	20	NF
19-Jun-17	90.1	20	M	18-Jul-17	70.8	13	NF
19-Jun-17	90.2	21	M	18-Jul-17	70.9	11	NF
19-Jun-17	90.2	14	M	18-Jul-17	71.2	22	NF
19-Jun-17	90.2	11	M	18-Jul-17	71.2	12	NF
19-Jun-17	90.4	22	M	18-Jul-17	71.4	18	NF
19-Jun-17	90.6	13	M	18-Jul-17	71.4	17	NF
19-Jun-17	90.8	3	M	18-Jul-17	71.6	20	NF
19-Jun-17	91.5	27	M	18-Jul-17	71.8	11	NF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
19-Jun-17	92.7	22	M	18-Jul-17	71.9	22	NF
19-Jun-17	5.0	18	I	18-Jul-17	72.0	21	NF
19-Jun-17	5.0	5	I	18-Jul-17	72.0	20	NF
19-Jun-17	8.2	1	I	18-Jul-17	72.0	13	NF
19-Jun-17	8.6	31	I	18-Jul-17	72.1	20	NF
19-Jun-17	10.6	11	NF	18-Jul-17	72.2	12	NF
19-Jun-17	10.6	6	NF	18-Jul-17	72.5	17	NF
19-Jun-17	11.4	11	NF	18-Jul-17	72.6	13	NF
19-Jun-17	12.4	10	NF	18-Jul-17	72.6	12	NF
19-Jun-17	14.1	23	NF	18-Jul-17	72.8	20	NF
19-Jun-17	37.3	7	NF	18-Jul-17	72.8	15	NF
19-Jun-17	40.6	31	NF	18-Jul-17	72.9	17	NF
19-Jun-17	52.0	23	NF	18-Jul-17	72.9	11	NF
19-Jun-17	55.0	23	NF	18-Jul-17	73.1	12	NF
19-Jun-17	60.7	29	NF	18-Jul-17	73.2	10	NF
19-Jun-17	61.0	27	NF	18-Jul-17	73.3	15	NF
19-Jun-17	61.4	27	NF	18-Jul-17	73.3	12	NF
19-Jun-17	62.9	23	NF	18-Jul-17	73.5	13	NF
19-Jun-17	64.0	23	NF	18-Jul-17	73.6	15	NF
19-Jun-17	65.8	13	NF	18-Jul-17	73.7	20	NF
19-Jun-17	68.3	29	NF	18-Jul-17	73.8	16	NF
19-Jun-17	68.5	17	NF	18-Jul-17	74.2	17	NF
19-Jun-17	68.5	15	NF	18-Jul-17	74.2	13	NF
19-Jun-17	69.6	23	NF	18-Jul-17	74.3	17	NF
19-Jun-17	69.7	24	NF	18-Jul-17	74.3	13	NF
19-Jun-17	70.0	15	NF	18-Jul-17	74.3	12	NF
19-Jun-17	70.0	13	NF	18-Jul-17	74.5	24	NF
19-Jun-17	70.5	14	NF	18-Jul-17	74.6	22	NF
19-Jun-17	70.8	13	NF	18-Jul-17	74.6	21	NF
19-Jun-17	70.8	13	NF	18-Jul-17	74.6	20	NF
19-Jun-17	70.8	9	NF	18-Jul-17	74.8	17	NF
19-Jun-17	70.8	8	NF	18-Jul-17	74.8	3	NF
19-Jun-17	70.8	7	NF	18-Jul-17	74.9	23	NF
19-Jun-17	71.2	15	NF	18-Jul-17	75.0	17	NF
19-Jun-17	71.7	36	NF	18-Jul-17	75.2	13	NF
19-Jun-17	72.7	16	NF	18-Jul-17	75.4	12	NF
19-Jun-17	72.8	23	NF	18-Jul-17	75.5	11	NF
19-Jun-17	73.6	8	NF	18-Jul-17	75.6	18	NF
19-Jun-17	73.9	31	NF	18-Jul-17	75.9	17	NF
19-Jun-17	75.6	16	NF	18-Jul-17	76.0	23	NF
19-Jun-17	75.7	13	NF	18-Jul-17	76.0	20	NF
19-Jun-17	75.9	19	NF	18-Jul-17	76.3	12	NF
19-Jun-17	78.2	35	NF	18-Jul-17	76.4	15	NF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex
19-Jun-17	79.8	12	NF
19-Jun-17	80.1	12	NF
19-Jun-17	80.1	11	NF
19-Jun-17	80.1	11	NF
19-Jun-17	80.6	11	NF
19-Jun-17	6.5	11	I
19-Jun-17	8.7	10	I
19-Jun-17	60.5	13	OF
19-Jun-17	64.5	5	OF
19-Jun-17	64.8	24	OF
19-Jun-17	65.0	10	OF
19-Jun-17	65.2	6	OF
19-Jun-17	68.7	19	OF
19-Jun-17	70.1	18	OF
19-Jun-17	70.5	21	OF
19-Jun-17	70.8	14	OF
19-Jun-17	70.8	10	OF
19-Jun-17	75.0	16	OF
19-Jun-17	75.4	16	OF
19-Jun-17	76.8	9	OF
19-Jun-17	80.1	15	OF
20-Jun-17	10.2	40	M
20-Jun-17	10.7	40	M
20-Jun-17	10.8	39	M
20-Jun-17	11.1	38	M
20-Jun-17	11.1	38	M
20-Jun-17	12.3	36	M
20-Jun-17	12.6	31	M
20-Jun-17	12.6	13	M
20-Jun-17	12.7	35	M
20-Jun-17	15.7	40	M
20-Jun-17	15.9	40	M
20-Jun-17	19.1	22	M
20-Jun-17	20.3	3	M
20-Jun-17	20.4	12	M
20-Jun-17	28.7	37	M
20-Jun-17	30.4	32	M
20-Jun-17	43.9	39	M
20-Jun-17	50.2	29	M
20-Jun-17	50.8	1	M
20-Jun-17	57.7	22	M
20-Jun-17	60.9	19	M
20-Jun-17	65.9	22	M
18-Jul-17	76.5	13	NF
18-Jul-17	76.8	31	NF
18-Jul-17	76.8	11	NF
18-Jul-17	77.0	21	NF
18-Jul-17	77.1	14	NF
18-Jul-17	77.2	18	NF
18-Jul-17	77.3	23	NF
18-Jul-17	77.4	13	NF
18-Jul-17	77.7	22	NF
18-Jul-17	77.7	13	NF
18-Jul-17	77.8	9	NF
18-Jul-17	77.9	20	NF
18-Jul-17	78.0	12	NF
18-Jul-17	78.2	15	NF
18-Jul-17	78.3	30	NF
18-Jul-17	78.5	31	NF
18-Jul-17	78.5	31	NF
18-Jul-17	78.5	21	NF
18-Jul-17	78.6	16	NF
18-Jul-17	78.6	16	NF
18-Jul-17	79.9	21	NF
18-Jul-17	80.0	22	NF
18-Jul-17	80.0	14	NF
18-Jul-17	80.1	16	NF
18-Jul-17	80.1	12	NF
18-Jul-17	80.8	11	NF
18-Jul-17	82.6	15	NF
18-Jul-17	84.5	15	NF
18-Jul-17	85.2	21	NF
18-Jul-17	85.4	30	NF
18-Jul-17	91.3	13	NF
18-Jul-17	75.7	29	OF
18-Jul-17	78.8	3	OF
19-Jul-17	77.3	33	M
19-Jul-17	66.2	30	NF
19-Jul-17	67.3	20	NF
19-Jul-17	67.6	23	NF
19-Jul-17	70.4	17	NF
19-Jul-17	72.5	12	NF
19-Jul-17	72.8	17	NF
19-Jul-17	72.9	13	NF
19-Jul-17	73.0	12	NF
19-Jul-17	73.2	15	NF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
20-Jun-17	68.2	21	M	19-Jul-17	73.4	25	NF
20-Jun-17	70.5	27	M	19-Jul-17	74.2	20	NF
20-Jun-17	70.8	31	M	19-Jul-17	74.5	16	NF
20-Jun-17	70.8	27	M	19-Jul-17	74.6	17	NF
20-Jun-17	70.8	19	M	19-Jul-17	74.7	25	NF
20-Jun-17	70.8	12	M	19-Jul-17	75.5	23	NF
20-Jun-17	70.9	16	M	19-Jul-17	76.9	25	NF
20-Jun-17	71.2	19	M	19-Jul-17	76.9	16	NF
20-Jun-17	71.2	15	M	19-Jul-17	78.1	15	NF
20-Jun-17	71.5	33	M	19-Jul-17	78.3	12	NF
20-Jun-17	71.8	19	M	19-Jul-17	79.3	23	NF
20-Jun-17	71.9	32	M	19-Jul-17	80.1	31	NF
20-Jun-17	72.5	32	M	19-Jul-17	80.8	15	NF
20-Jun-17	73.2	18	M	19-Jul-17	80.9	20	NF
20-Jun-17	73.4	21	M	19-Jul-17	82.1	39	NF
20-Jun-17	73.6	23	M	19-Jul-17	9.7	16	I
20-Jun-17	74.1	18	M	19-Jul-17	79.0	13	OF
20-Jun-17	76.8	15	M	20-Jul-17	68.4	16	NF
20-Jun-17	78.5	33	M	20-Jul-17	70.8	19	NF
20-Jun-17	79.8	11	M	20-Jul-17	71.9	23	NF
20-Jun-17	79.9	21	M	20-Jul-17	72.6	15	NF
20-Jun-17	80.1	14	M	20-Jul-17	72.9	20	NF
20-Jun-17	80.2	16	M	20-Jul-17	74.3	19	NF
20-Jun-17	80.2	10	M	20-Jul-17	76.3	20	NF
20-Jun-17	80.4	18	M	20-Jul-17	77.3	15	NF
20-Jun-17	80.5	29	M	20-Jul-17	78.1	16	NF
20-Jun-17	80.5	27	M	20-Jul-17	78.2	19	NF
20-Jun-17	80.5	16	M	20-Jul-17	78.7	24	NF
20-Jun-17	80.8	19	M	20-Jul-17	79.4	20	NF
20-Jun-17	80.8	12	M	20-Jul-17	83.1	7	NF
20-Jun-17	83.7	22	M	20-Jul-17	83.4	19	NF
20-Jun-17	85.0	33	M	20-Jul-17	63.4	19	OF
20-Jun-17	85.7	19	M	20-Jul-17	70.1	12	OF
20-Jun-17	85.7	16	M	20-Jul-17	72.6	13	OF
20-Jun-17	86.0	34	M	20-Jul-17	75.0	13	OF
20-Jun-17	86.2	18	M	20-Jul-17	76.9	11	OF
20-Jun-17	86.9	24	M	20-Jul-17	77.1	11	OF
20-Jun-17	87.0	21	M	20-Jul-17	77.1	2	OF
20-Jun-17	87.8	24	M	20-Jul-17	77.4	39	OF
20-Jun-17	90.6	16	M	20-Jul-17	78.2	20	OF
20-Jun-17	90.9	20	M	20-Jul-17	79.6	13	OF
20-Jun-17	91.2	19	M	20-Jul-17	80.0	16	OF
20-Jun-17	92.1	15	M	20-Jul-17	82.2	27	OF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
20-Jun-17	3.6	13	I	21-Jul-17	87.9	12	M
20-Jun-17	5.0	35	I	21-Jul-17	62.3	20	NF
20-Jun-17	5.2	32	I	21-Jul-17	67.8	21	NF
20-Jun-17	5.6	31	I	21-Jul-17	70.4	19	NF
20-Jun-17	5.6	21	I	21-Jul-17	71.7	19	NF
20-Jun-17	5.8	31	I	21-Jul-17	72.1	19	NF
20-Jun-17	5.8	31	I	21-Jul-17	72.9	21	NF
20-Jun-17	5.9	24	I	21-Jul-17	74.6	21	NF
20-Jun-17	6.2	32	I	21-Jul-17	79.2	19	NF
20-Jun-17	6.2	30	I	21-Jul-17	59.1	20	OF
20-Jun-17	6.4	31	I	21-Jul-17	63.9	17	OF
20-Jun-17	6.4	12	I	21-Jul-17	64.1	11	OF
20-Jun-17	6.5	24	I	21-Jul-17	71.1	30	OF
20-Jun-17	6.7	15	I	21-Jul-17	71.4	3	OF
20-Jun-17	6.8	34	I	21-Jul-17	71.8	34	OF
20-Jun-17	6.8	24	I	21-Jul-17	72.5	6	OF
20-Jun-17	6.8	3	I	21-Jul-17	74.4	12	OF
20-Jun-17	6.9	26	I	21-Jul-17	75.6	26	OF
20-Jun-17	7.8	34	I	21-Jul-17	76.1	16	OF
20-Jun-17	8.4	30	I	21-Jul-17	76.3	16	OF
20-Jun-17	8.5	26	I	21-Jul-17	77.2	13	OF
20-Jun-17	8.6	26	I	21-Jul-17	77.4	22	OF
20-Jun-17	8.6	18	I	21-Jul-17	77.6	15	OF
20-Jun-17	8.8	33	I	21-Jul-17	79.6	15	OF
20-Jun-17	9.8	29	I	21-Jul-17	85.8	17	OF
20-Jun-17	12.2	12	NF	24-Jul-17	12.2	14	M
20-Jun-17	12.9	15	NF	24-Jul-17	12.5	38	M
20-Jun-17	14.1	4	NF	24-Jul-17	14.6	24	M
20-Jun-17	16.9	8	NF	24-Jul-17	14.7	38	M
20-Jun-17	24.9	5	NF	24-Jul-17	64.0	24	M
20-Jun-17	44.6	17	NF	24-Jul-17	74.4	17	M
20-Jun-17	47.2	22	NF	24-Jul-17	74.6	14	M
20-Jun-17	56.7	12	NF	24-Jul-17	75.0	27	M
20-Jun-17	58.3	25	NF	24-Jul-17	75.5	15	M
20-Jun-17	60.0	14	NF	24-Jul-17	76.0	20	M
20-Jun-17	62.4	15	NF	24-Jul-17	76.6	24	M
20-Jun-17	65.2	16	NF	24-Jul-17	78.4	18	M
20-Jun-17	68.8	5	NF	24-Jul-17	80.3	21	M
20-Jun-17	70.6	15	NF	24-Jul-17	80.6	15	M
20-Jun-17	70.8	16	NF	24-Jul-17	80.8	22	M
20-Jun-17	70.8	16	NF	24-Jul-17	81.0	20	M
20-Jun-17	70.8	12	NF	24-Jul-17	82.6	11	M
20-Jun-17	70.9	15	NF	24-Jul-17	82.9	12	M

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
20-Jun-17	71.2	16	NF	24-Jul-17	83.2	20	M
20-Jun-17	71.5	33	NF	24-Jul-17	84.7	15	M
20-Jun-17	71.6	15	NF	24-Jul-17	85.0	15	M
20-Jun-17	72.4	15	NF	24-Jul-17	90.3	11	M
20-Jun-17	76.8	2	NF	24-Jul-17	9.4	23	I
20-Jun-17	78.7	15	NF	24-Jul-17	56.2	20	NF
20-Jun-17	78.8	10	NF	24-Jul-17	62.4	22	NF
20-Jun-17	78.9	15	NF	24-Jul-17	63.4	28	NF
20-Jun-17	80.0	14	NF	24-Jul-17	63.9	18	NF
20-Jun-17	80.1	13	NF	24-Jul-17	63.9	12	NF
20-Jun-17	80.1	10	NF	24-Jul-17	67.2	20	NF
20-Jun-17	80.5	16	NF	24-Jul-17	67.7	15	NF
20-Jun-17	80.5	15	NF	24-Jul-17	67.9	9	NF
20-Jun-17	82.8	18	NF	24-Jul-17	68.3	20	NF
20-Jun-17	4.8	24	I	24-Jul-17	68.3	11	NF
20-Jun-17	5.8	22	I	24-Jul-17	68.8	20	NF
20-Jun-17	8.3	26	I	24-Jul-17	68.9	17	NF
20-Jun-17	8.5	24	I	24-Jul-17	69.2	20	NF
20-Jun-17	71.1	34	OF	24-Jul-17	69.4	23	NF
20-Jun-17	75.4	16	OF	24-Jul-17	69.8	20	NF
22-Jun-17	11.5	6	M	24-Jul-17	70.4	20	NF
22-Jun-17	13.8	6	M	24-Jul-17	70.5	23	NF
22-Jun-17	15.0	10	M	24-Jul-17	70.6	24	NF
22-Jun-17	15.4	8	M	24-Jul-17	71.1	24	NF
22-Jun-17	18.6	3	M	24-Jul-17	71.2	21	NF
22-Jun-17	25.6	9	M	24-Jul-17	71.5	20	NF
22-Jun-17	70.8	12	M	24-Jul-17	71.5	18	NF
22-Jun-17	74.4	5	M	24-Jul-17	72.2	33	NF
22-Jun-17	76.3	5	M	24-Jul-17	72.5	18	NF
22-Jun-17	78.3	24	M	24-Jul-17	72.8	23	NF
22-Jun-17	83.3	8	M	24-Jul-17	73.3	23	NF
22-Jun-17	84.7	33	M	24-Jul-17	73.4	11	NF
22-Jun-17	85.2	38	M	24-Jul-17	73.5	1	NF
22-Jun-17	87.7	13	M	24-Jul-17	73.6	21	NF
22-Jun-17	5.0	8	I	24-Jul-17	74.7	12	NF
22-Jun-17	5.0	6	I	24-Jul-17	74.7	9	NF
22-Jun-17	54.7	1	NF	24-Jul-17	75.3	21	NF
22-Jun-17	65.5	12	NF	24-Jul-17	76.3	26	NF
22-Jun-17	69.0	14	NF	24-Jul-17	76.5	15	NF
22-Jun-17	73.1	18	NF	24-Jul-17	76.7	21	NF
22-Jun-17	73.1	14	NF	24-Jul-17	76.9	20	NF
22-Jun-17	74.3	10	NF	24-Jul-17	77.3	21	NF
22-Jun-17	75.6	10	NF	24-Jul-17	77.7	18	NF

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex	Date	CW	RS	Sex
22-Jun-17	76.0	14	NF	24-Jul-17	77.8	26	NF
22-Jun-17	78.2	27	NF	24-Jul-17	78.0	20	NF
22-Jun-17	69.8	19	OF	24-Jul-17	78.3	26	NF
22-Jun-17	71.4	22	OF	24-Jul-17	78.5	18	NF
23-Jun-17	12.4	14	M	24-Jul-17	79.9	15	NF
23-Jun-17	13.9	23	M	24-Jul-17	81.1	20	NF
23-Jun-17	58.6	39	M	24-Jul-17	81.1	12	NF
23-Jun-17	66.5	25	M	24-Jul-17	81.3	18	NF
23-Jun-17	67.3	31	M	24-Jul-17	81.5	18	NF
23-Jun-17	71.9	10	M	24-Jul-17	81.5	8	NF
23-Jun-17	72.4	14	M	24-Jul-17	84.2	15	NF
23-Jun-17	74.3	22	M	24-Jul-17	84.9	10	NF
23-Jun-17	74.8	22	M	25-Jul-17	10.9	25	M
23-Jun-17	75.3	24	M	25-Jul-17	13.0	36	M
23-Jun-17	76.0	26	M	25-Jul-17	13.0	32	M
23-Jun-17	76.5	23	M	25-Jul-17	14.4	38	M
23-Jun-17	77.4	25	M	25-Jul-17	62.6	25	M
23-Jun-17	77.6	15	M	25-Jul-17	72.4	18	M
23-Jun-17	78.2	12	M	25-Jul-17	73.3	16	M
23-Jun-17	78.4	6	M	25-Jul-17	78.3	16	M
23-Jun-17	79.2	15	M	25-Jul-17	78.4	11	M
23-Jun-17	79.9	18	M	25-Jul-17	79.3	24	M
23-Jun-17	80.5	40	M	25-Jul-17	80.9	12	M
23-Jun-17	80.5	22	M	25-Jul-17	82.5	31	M
23-Jun-17	81.2	20	M	25-Jul-17	84.5	18	M
23-Jun-17	81.3	24	M	25-Jul-17	93.2	2	M
23-Jun-17	81.4	21	M	25-Jul-17	94.0	16	M
23-Jun-17	82.0	14	M	25-Jul-17	8.5	13	I
23-Jun-17	82.2	14	M	25-Jul-17	9.2	32	I
23-Jun-17	82.2	9	M	25-Jul-17	55.2	3	NF
23-Jun-17	82.3	23	M	25-Jul-17	62.3	18	NF
23-Jun-17	83.2	31	M	25-Jul-17	63.4	1	NF
23-Jun-17	83.5	16	M	25-Jul-17	67.7	6	NF
23-Jun-17	84.1	22	M	25-Jul-17	69.2	29	NF
23-Jun-17	84.3	15	M	25-Jul-17	71.6	7	NF
23-Jun-17	84.6	15	M	25-Jul-17	72.5	19	NF
23-Jun-17	84.7	14	M	25-Jul-17	73.2	12	NF
23-Jun-17	84.8	14	M	25-Jul-17	73.3	14	NF
23-Jun-17	84.9	22	M	25-Jul-17	74.2	12	NF
23-Jun-17	85.3	13	M	25-Jul-17	75.3	23	NF
23-Jun-17	85.7	17	M	25-Jul-17	76.8	22	NF
23-Jun-17	85.8	15	M	26-Jul-17	78.1	21	M
23-Jun-17	85.9	15	M	26-Jul-17	83.1	21	M

Appendix A3 (continued). Raw data for *Gecarcinus ruricola* (Chapter 3, Chapter 4).

Date	CW	RS	Sex
23-Jun-17	86.0	22	M
23-Jun-17	86.4	9	M
23-Jun-17	86.8	22	M
23-Jun-17	86.9	15	M
23-Jun-17	87.1	13	M
23-Jun-17	87.3	29	M
23-Jun-17	88.6	14	M
23-Jun-17	88.7	14	M
23-Jun-17	89.9	24	M
23-Jun-17	90.2	16	M
23-Jun-17	92.2	18	M
23-Jun-17	97.6	23	M
23-Jun-17	6.6	5	I
23-Jun-17	15.1	10	NF
23-Jun-17	19.5	16	NF
23-Jun-17	61.5	13	NF
23-Jun-17	64.7	12	NF
23-Jun-17	66.2	19	NF
23-Jun-17	67.4	27	NF
23-Jun-17	67.8	9	NF
23-Jun-17	68.5	13	NF
23-Jun-17	69.5	12	NF
23-Jun-17	70.2	17	NF
23-Jun-17	70.5	14	NF
23-Jun-17	71.0	14	NF
23-Jun-17	71.1	13	NF
23-Jun-17	71.3	9	NF
23-Jun-17	71.4	23	NF
23-Jun-17	71.7	11	NF
23-Jun-17	72.2	13	NF
26-Jul-17	64.5	12	NF
26-Jul-17	68.3	19	NF
26-Jul-17	71.6	29	NF
26-Jul-17	74.6	24	NF
27-Jul-17	75.8	19	M
27-Jul-17	83.7	17	M
27-Jul-17	86.4	13	M
27-Jul-17	84.2	15	NF
28-Jul-17	71.1	20	M
28-Jul-17	72.0	22	M
28-Jul-17	74.0	18	M
28-Jul-17	74.9	19	M
28-Jul-17	78.4	15	M
28-Jul-17	81.0	14	M
28-Jul-17	82.5	21	M
28-Jul-17	82.9	23	M
28-Jul-17	69.0	20	NF
28-Jul-17	73.2	18	NF
29-Jul-17	60.6	13	OF
2-Aug-17	63.4	20	OF
2-Aug-17	68.4	1	OF
2-Aug-17	77.1	6	OF
5-Aug-17	76.5	12	M
5-Aug-17	79.9	10	M
5-Aug-17	70.1	2	NF
5-Aug-17	70.7	12	NF
5-Aug-17	75.1	12	NF
5-Aug-17	79.7	4	NF
5-Aug-17	81.1	11	NF

Appendix A4. Dominant flora identified at Barkers National Park, West Bay, Grand Cayman in July, 2017. The survey protocol was similar to methods described in Chapter 3. A species was considered dominant if it occurred in at least 20% of the sampling area.

Scientific Name	Common Name
Avicennia germinans	Black mangrove
Blutaparon vermiculare	Silverhead
Bourreria venosa	Parrot berry
Bursera simaruba	Red birch
Caesalpinia bonduc	Cockspur, Grey nickel
Casuarina equisetifolia	Casuarina, Australian pine
Chamaesyce mesembryanthemifolia	Coastal beach sandmat
Chiococca alba	West Indian milkberry
Chrysobalanus icaco	Cocoplum
Coccoloba uvifera	Sea grape
Coccothrinax proctorii	Silver thatch palm
Cocos nucifera	Coconut palm
Colubrina asiatica	Latherleaf, Asian snakewood
Comocladia dentata	Maiden plum
Conocarpus erectus	Buttonwood
Cordia sebestena	Broadleaf, Geiger tree
Croton linearis	Grannybush
Ernodea littoralis	Golden creeper, Beach creeper
Eugenia axillaris	White stopper
Guapira discolor	Cabbage tree
Gyminda latifolia	West Indian false box
Ipomodea indica var. acuminate	Blue morning glory
Laguncularia racemose	White mangrove
Lantana involucrata	Buttonsage
Leucaena leucocephala	Wild tamarind
Morinda royoc	Noni, Cheese fruit
Randia aculeata	White indigoberry
Rhizophora mangle	Red mangrove
Scaevola taccada	Beach naupaka
Suriana maritima	Bay cedar
Tamarindus indica	Tamarind
Thespesia populnea	Plopnut
Thrinax radiata	Bull thatch

Appendix A5. Starting location for each marked 100m road section (1-40) along Queen's Highway, East End, Grand Cayman (Chapter 4).

RS	Distance (m)	Latitude	Longitude
1	0-100	19° 21' 8.6" N	81° 8' 16.5" W
2	100-200	19° 21' 4.4" N	81° 9' 21.9" W
3	200-300	19° 21' 4.9" N	81° 9' 18.9" W
4	300-400	19° 21' 6.1" N	81° 9' 15.1" W
5	400-500	19° 21' 7.2" N	81° 9' 11.5" W
6	500-600	19° 21' 8.0" N	81° 9' 8.1" W
7	600-700	19° 21' 8.1" N	81° 9' 5.1" W
8	700-800	19° 21' 8.2" N	81° 9' 0.9" W
9	800-900	19° 21' 8.0" N	81° 8' 57.1" W
10	900-1000	19° 21' 7.9" N	81° 8' 53.7" W
11	1000-1100	19° 21' 8.0" N	81° 8' 49.7" W
12	1100-1200	19° 21' 7.7" N	81° 8' 46.3" W
13	1200-1300	19° 21' 7.3" N	81° 8' 42.8" W
14	1300-1400	19° 21' 6.8" N	81° 8' 39.0" W
15	1400-1500	19° 21' 6.5" N	81° 8' 35.5" W
16	1500-1600	19° 21' 6.5" N	81° 8' 31.8" W
17	1600-1700	19° 21' 6.9" N	81° 8' 28.1" W
18	1700-1800	19° 21' 7.5" N	81° 8' 24.5" W
19	1800-1900	19° 21' 8.0" N	81° 8' 20.9" W
20	1900-2000	19° 21' 8.6" N	81° 8' 17.3" W
21	2000-2100	19° 21' 9.1" N	81° 8' 13.7" W
22	2100-2200	19° 21' 9.6" N	81° 8' 10.1" W
23	2200-2300	19° 21' 10.2" N	81° 8' 6.5" W
24	2300-2400	19° 21' 10.7" N	81° 8' 2.8" W
25	2400-2500	19° 21' 11.3" N	81° 7' 59.2" W
26	2500-2600	19° 21' 11.9" N	81° 7' 55.5" W
27	2600-2700	19° 21' 12.4" N	81° 7' 51.9" W
28	2700-2800	19° 21' 12.7" N	81° 7' 48.2" W
29	2800-2900	19° 21' 12.7" N	81° 7' 44.4" W
30	2900-3000	19° 21' 12.6" N	81° 7' 40.7" W
31	3000-3100	19° 21' 12.7" N	81° 7' 37.2" W
32	3100-3200	19° 21' 12.6" N	81° 7' 33.5" W
33	3200-3300	19° 21' 12.6" N	81° 7' 29.9" W
34	3300-3400	19° 21' 12.6" N	81° 7' 26.1" W
35	3400-3500	19° 21' 12.5" N	81° 7' 22.5" W
36	3500-3600	19° 21' 12.4" N	81° 7' 18.9" W
37	3600-3700	19° 21' 12.2" N	81° 7' 15.2" W
38	3700-3800	19° 21' 11.6" N	81° 7' 11.5" W
39	3800-3900	19° 21' 11.0" N	81° 7' 7.9" W
40	3900-4000	19° 21' 10.4" N	81° 7' 4.4" W

Appendix A6. Specific locations within the 40 road sections (850m^2) on Queen's Highway with the highest *G. ruricola* roadkills in 2017.

RS	Latitude	Longitude
11	19° 21' 7.8" N	81° 8' 49.1" W
12	19° 21' 7.3" N	81° 8' 44.9" W
12	19° 21' 7.4" N	81° 9' 43.2" W
13	19° 21' 7.0" N	81° 8' 40.3" W
14	19° 21' 6.5" N	81° 8' 35.3" W
14	19° 21' 6.6" N	81° 8' 32.6" W
16	19° 21' 6.9" N	81° 8' 29.7" W
17	19° 21' 7.2" N	81° 8' 27.1" W
17	19° 21' 7.5" N	81° 8' 25.5" W
18	19° 21' 7.8" N	81° 8' 24.0" W
18	19° 21' 8.1" N	81° 8' 22.0" W
19	19° 21' 8.2" N	81° 8' 20.6" W
19	19° 21' 8.6" N	81° 8' 18.6" W
19	19° 21' 8.4" N	81° 8' 17.2" W
20	19° 21' 8.8" N	81° 8' 16.3" W
21	19° 21' 9.3" N	81° 8' 13.4" W