MOLECULAR ANALYSIS OF HAEMOGREGARINIDAE IN FRESHWATER TURTLES

by

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DEDICATION

To the Nerdmeyers, for their love, support, and sass.

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ABSTRACT

Habitat fragmentation and other environmental stressors are major factors in declines of biodiversity and can impact specific animal populations. To aid in conservation efforts, individuals from impacted populations may be removed from at-risk areas, captive propagated, and the offspring subsequently released into the environment. This strategy is commonly applied to conservation efforts for turtle populations. These turtles are often stressed when entering captive populations, and consequently are more susceptible to diseases. Captive propagation may also increase the risk of disease or parasite transmission due to high density propagation and transport. In freshwater turtles, the most common blood parasites are specifically represented by members of Haemogregarinidae; *Haemogregarina*, *Hemolivia* and *Hepatozoon*. I determined the prevalence of these blood parasites and related the infecting parasite species to turtle species. Previously, collected samples from eight locations were classified as Wild, Captive, or Wild Caught Captive Raised, which comprised of 326 blood samples from six turtle families; Bataguridae, Chelidae, Emydidae, Kinosternidae, Pelomedusidae, and Trionychidae. SybrGreen-based *q*PCR detected Haemogregarinidae in 88 of these samples–53% of individuals belonging to Bataguridae, 26% belonging to Emydidae and 23% belonging to Kinosternidae. Comparative sequence analyses of 18S rRNA gene fragments (633 basepairs) representing members of the Haemogregarinidae identified 73 *Haemogregarina* infections, 2 *Hepatozoon* infections, and 1 *Hemolivia* infection.

I. INTRODUCTION

A large variety of environmental stressors, that include habitat destruction and fragmentation by urban and agricultural growth, or related fertilizer and chemical run off have been identified as underlying reasons for steep declines of turtle populations, with effects on both turtle abundance and diversity (Dresser et al., 2017; Gibbons et al., 2000). As habitats become unsuitable for turtle populations, competition in the remaining habitats will increase with species competing for food sources and basking sites (Polo-Cavia et al., 2012). Turtles are highly susceptible to potentially toxic pollutants, which can cause mortality or may lead to long-term effects on sex determination (Gibbons et al., 2000). For example, polychlorinated biphenyls might act as endocrine-disruptors, and exposed turtles may undergo sex reversal or develop abnormal gonads (Gibbons et al., 2000).

In an attempt to conserve the biodiversity of turtles and increase their numbers at specific sites, turtles are often removed from at-risk areas, captive propagated and their offspring released into adequate environments (Hartley & Sainsbury, 2017). A major concern of these attempts; however, is the potential introduction of diseases into the environment through infected offspring (Verneau et al., 2011). Turtles are extremely sensitive to diseases and are affected by more diseases than any other reptilian group (Dodd, 2016). Any disease in a released turtle could be transmitted from an introduced host to an indigenous animal, which could result in more severe infections of naïve animals as they may lack the acquired immunity needed to protect them (Divers & Mader, 2005; Hartley & Sainsbury, 2017). This problem is not restricted to reintroduction of offspring of endangered turtle species but is also a concern for rescued or confiscated turtle species. In many Asian countries, turtles are frequently traded for both food and herbal remedies, thus many native turtle species are in danger of becoming extinct (Gibbons et al., 2000). Confiscated turtles from the Asian trade market are sometimes transported to new locations, where the release of infected turtles could result in the concomitant release of pathogens into the environment. If native species become infected by a novel pathogen, it may become more difficult for them to outcompete other turtle species, such as invasive species like *Trachemys scripta elegans* (Verneau et al., 2011).

Risk of transmission can also be increased during transport of the animals – traveling in trucks with stacked cages, which is an easy way for infections to pass among animals, especially if specific vectors such as ticks and leeches are involved in parasite transmission (Jacobson, 1993). Reducing the presence of vectors such as leeches through water treatments by the addition of copper sulfate in the water is a common practice that deters the probability of turtles in captivity to become infected. Leeches are the most common ectoparasite in reptiles and have been identified as potent vectors especially for the transmission of blood parasites including Haemogregarinidae and *Trypanosoma chrysemydis* (Readel et al., 2008; Woo, 1969). Ideally, health and wellness screenings would be conducted prior to the release of captive animals into the wild, to reduce the chance of introducing blood parasites to native species (Hartley & Sainsbury, 2017). Thus, in addition to water treatments with Copper Sulfate for the removal of leeches on captive animals, these animals would be screened before and after transport in order to detect the presence of leeches as an indication for a potential parasitic infection. These screenings, however, do not always include a blood test in addition to the standard weight records and visual assessment (Hartley & Sainsbury, 2017).

Freshwater turtles utilize basking to thermoregulate, which also aids in digestion and discourages leeches (Polo-Cavia et al., 2012; Readel et al., 2008). Leech load is determined by a number of factors, including the amount of soft tissue on a turtle where leeches can attach and feed, as well as overall turtle body size (Readel et al., 2008). The more space available for a leech to attach, the more likely that a turtle may become infected by a blood parasite. Leech load may also differ by the type of site used for basking. Turtles differ in which habitats they prefer, based on their tolerance for disturbance by other animals or humans, as well as a number of ecological factors including water and air temperature, water depth, substrate type and amount of shading (Lambert et al., 2013). These factors may be altered due to environmental pollution and global climate change, which are also potential causes for declines in population density (Gibbons et al., 2000).

As the number of optimal habitats decrease, species that are more specific in their habitat needs may face declines in population numbers, while species that are more generalists will have an easier time adjusting to a new habitat (Lambert et al., 2013). Habitat fragmentation, from natural and anthropogenic causes, may lead to a reduction in biodiversity, which in turn can lead to increased disease transmission, as there is a greater chance for the remaining turtle species to become infected by a feeding leech (Fahrig, 2003; Keesing et al., 2010). The more turtles infected, the greater the chance of a leech becoming infected, continuing the cycle and leading to higher rates of disease prevalence.

There are currently 258 turtles on the IUCN red list, ranging from near threatened to extinct. To be added to this list, a species must (1) have a population size that falls below a definitive quantitative threshold, (2) have a small population size that is facing further population declines, or (3) is confined to a small geographic area (Harris et al., 2012). For this study, blood samples of 29 turtle species were analyzed. These turtles represented six families: the Bataguridae, Chelidae, Emydidae, Kinosternidae, Pelomedusidae, and Trionychidae (Table 1). Six of the 29 species are listed on the IUCN Red List of Threatened Species. *Elseya branderhorsti, Hardella thurjii, Heosemys grandis, Malaclemys terrapin* and *Siebenrockiella crassicollis* are each listed as vulnerable, while *Chelodina mccordi* is listed as critically endangered.

Table 1: Number of individuals sampled from each turtle species (N) with positive and negative detections of Haemogregarinidae in blood samples as determined by *q*PCR detection of Haemogregarinidae-specific 18S rRNA gene fragments.

Family	Genus	Species	Subspecies	N	Positive	Negative
Bataguridae	*Callagur*	*borneoensis*		7	0	7
	Cyclemys	*dentata*		4	2	2
	Geoemyda	*nigrican*		1	0	1
	Hardella	*thurjii*		1	1	0
	Heosemys	*grandis*		22	13	9
	Hieremys	*annandalii*		1	1	0
	Orlitia	*borneensis*		10	0	10
	Rhinoclemmys	*punctularia*		1	0	1
	Sacalia	*bealeyi*		2	1	1
	Siebenrockiella	*crassicollis*		8	4	4
Chelidae	*Chelodina*	*siebenrocki*		6	0	6
	Chelodina	*mccordi*		2	0	2
	Elseya	*branderhorstii*		11	0	11
	Emydura	*subglobosa*		5	0	5
	Phrynops	*gibbus*		3	0	3
	Phrynops	*platycephala*		2	0	2
	Phrynops	*geoffroanus*		3	0	3
Emydidae	*Chrysemys*	*picta*	*belli*	1	0	1
	Graptemys	*versa*		5	3	2
	Malaclemys	*terrapin*		4	0	4
	Pseudemys	*texana*		27	13	14
	Pseudemys	*nelsoni*		2	2	0
	Pseudemys	*gorzugi*		17	2	15
	Trachemys	*scripta*	*elegans*	180	25	155
Kinosternidae	*Kinosternon*	*sonoriense*		3	2	1
	Staurotypus	*triporcatus*		7	0	7
	Sternotherus	*odoratus*		91	1	90
Pelomedusidae	*Pelusios*	*subniger*		3	0	3
Trionychidae	*Trionyx (Apalone)*	*spinifera*		1	0	1

In freshwater turtles, blood parasites are specifically represented by members of the Haemogregarinidae. Three genera, *Haemogregarina*, *Hemolivia* and *Hepatozoon*, are the most common blood parasites found in different turtle species. Parasitic infections are described by data on prevalence and parasitemia (Maia, Harris, et al., 2016). Prevalence describes the number of infected individuals found within a population (Maia, Harris, et al., 2016). Parasitaemia is the number of parasites infecting a single individual (Maia, Harris, et al., 2016). These parameters are used in estimating host specificity and coevolution, especially in parasites with more complex life cycles (Ishtiaq et al., 2017; Maia, Harris, et al., 2016).

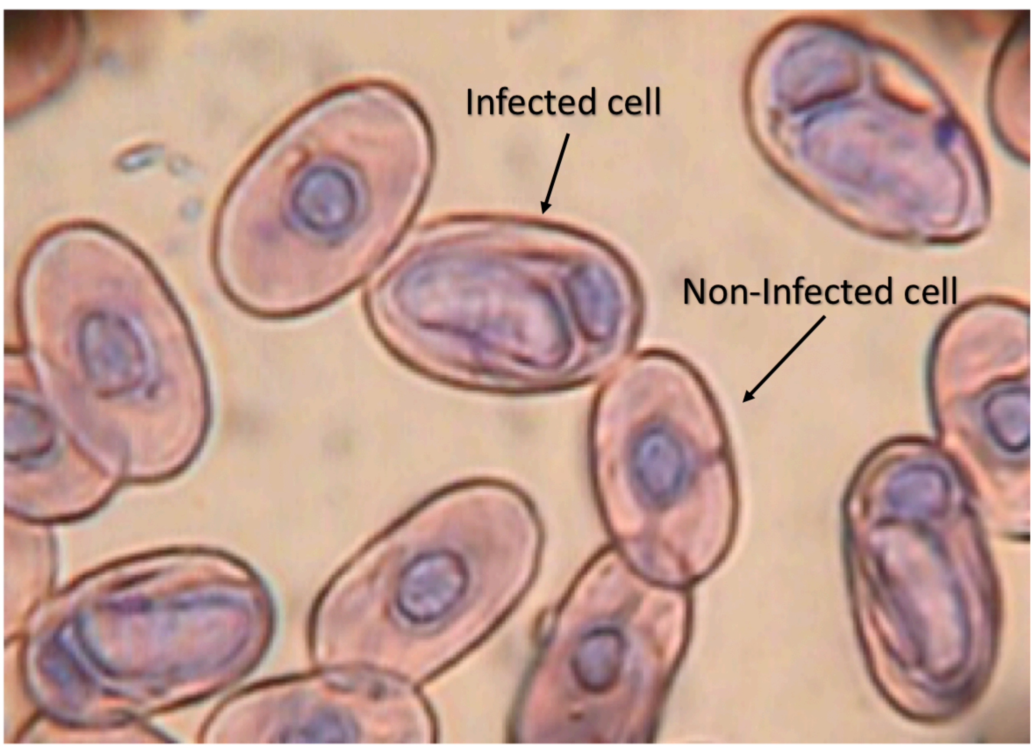

Figure 1: Image of mature gamonts in sample MF5807, from a *Trachemys scripta elegans* turtle. Four parasites can be seen infecting the turtle red blood cells (Lobban, 2003).

Infection of a host with Haemogregarinidae results in internal tissue damage as a consequence of a generalized tissue response to the blood parasites (Davies, 1995; Morrissette & Sibley, 2002). Microscopic examination of a blood smear shows a displaced host nucleus in infected cells that are also enlarged (Figure 1) (Rossow et al., 2013). Infection results in anemia, weakness and generally poor health conditions of the turtle hosts, along with limited motility and decreased growth rate (Maia et al., 2014; Ozvegy et al., 2015). There have been some reports of shell necrosis as well, accompanied by skin hemorrhages (Ozvegy et al., 2015). These, however, are not likely a direct result of the infection but may have been obtained as a result of slower movement and overall decrease in health that either modified basking behaviors or lowered immune system responses (Zimmerman et al., 2010).

First described in 1885 by Danilewsky, Haemogregarinidae are intraerythrocytic, parasitic protozoa (Siddall & Desser, 1991). They belong to the phylum Apicomplexa, suborder Adeleorina and family Haemogregarinidae (Ozvegy et al., 2015). These blood parasites are heteroxenous as they require two hosts to complete their life cycle; an invertebrate host and a vertebrate host (Dvorakova et al., 2014; Maia, Harris, et al., 2016). Hemogregarines utilize invertebrates hosts such as leeches; *Placobdella ornata* and *Placobdella parasitica* are common leech species known to transmit Haemogregarinidae infections (Paterson & Desser, 1976). Common vertebrate hosts are chelonians and lizards, as well as fish, birds, and mammals (Karadjian et al., 2015; Ozvegy et al., 2015; Rossow et al., 2013). Haemogregarinidae infections are widespread, although hosts exhibit low levels (<1%) of parasitemia (Rossow et al., 2013; Smit & Davies, 2001).

Knowing possible leech vectors is important, as morphological studies on leeches are used in determining the complete life cycle of Haemogregarinidae species (Siddall & Desser, 1991). Visualization of a Haemogregarinidae parasite in a blood sample from a leech vector is not required for identification of the parasite but can help further understand their lifecycle and differentiate between Haemogregarinidae species (Siddall & Desser, 1991). Some Haemogregarinidae parasites are host specific, while others are more generalists (Davies, 1995). This is supported by the detection of *Haemogregarina bigemina* in multiple species of fish (Davies et al., 2004). *Haemogregarina balli* has been reported in the snapping turtle *Chelydra serpentina*, and *H. stepanowi* has been reported in the freshwater turtles *Emys orbicularis* and *Mauremys caspica* (Javanbakht & Sharifi, 2014; Paterson & Desser, 1976). *Haemogregarina* species are difficult to distinguish from related species such as *Hepatozoon* and *Hemolivia* (Sloboda et al., 2007).

These parasites are often differentiated from one another based on histological observations, specifically regarding the oocytes in invertebrate hosts (Davies, 1995). *Hepatozoon* belongs to the phylum Apicomplexa, suborder Adeleorina (Maia et al., 2014). These parasites generally infect reptiles and utilize vectors such as ticks and mites (Maia et al., 2014; Moco et al., 2002). Similar to members of the genus *Haemogregarina*, *Hepatozoon* is heteroxenous and has a two-host life cycle (Maia et al., 2014). *Hemolivia* is another genus of parasite that can be mistaken for *Haemogregarina* and *vice versa* (Kvicerova et al., 2014). This parasite belongs to the phylum Apicomplexa, suborder Adeleorina, but has been assigned to the family Karyolysidae. An assignment to the genus *Hemolivia* is sometimes used as a generic solution for members of the phylum Apicomplexa with unresolved evolutionary history and/or taxonomy (Kvicerova et al., 2014). There is less difficulty in differentiating *Haemogregarina* from *Hemolivia*, as *Karyolysus* infections tend to occur in lizards and use a mite vector (Divers & Mader, 2005; Haklova-Kocikova et al., 2014). Strong similarities in morphological and life cycle characteristics among these species of blood parasites make it difficult to distinguish these species. *Haemogregarina*, for example, undergoes similar asexual development as *Hepatozoon* and Karyolysidae parasites (Siddall & Desser, 1991). While there are small details during each life cycle that can be used to differentiate between these differing blood parasites, detection and visualization of these specific stages of the life cycle are difficult (Karadjian et al., 2015).

As a result, current diagnostic procedures are not solely based on morphological data but incorporate molecular tools for use in identification of these blood parasites. Comparative sequence analyses of ribosomal RNA genes have been basis for many phylogenetic analyses of the Haemogregarinidae (Cook et al., 2014; Davies & Johnston, 2000; Ozvegy et al., 2015; Smit & Davies, 2001) and related parasites (Barta, 1989; Mathew et al., 2000; Siddall & Desser, 1991; Smith et al., 1999). The accuracy of these analyses, however, depends on available databases with clear correlations of morphological data to those of molecular data obtained for the same described species. The lack of comprehensive databases has resulted in some taxonomic confusion for the Haemogregarinidae, with one study assigning them to the class Coccidea, suborder Adeleina, while another assigned them to the class Sporozoasida, suborder Adeleorina (Ozvegy et al., 2015; Smit & Davies, 2001).

There have been instances were some of these parasites have been assigned to different genera, such as *Haemogregarina catesbianae* being reassigned as *Hepatozoon* *catesbianae* (Desser et al., 1995; Kim et al., 1998). *Karyolysus clamatae* was also assigned as *Hepatozoon* (Kim et al., 1998). Recent analyses show of *Haemogregarina* sp. separate from *Hepatozoon,* with *Hemolivia* paraphyletic to *Hepatozoon* (Maia, Carranza, et al., 2016). More sequence data is needed from these related groups before reliable species assignments can be expected.

Apicomplexan parasites have an elongated shape with an apical complex. This region of the parasite houses a few unique organelles, including rhoptries, micronemes, and the apical polar ring. Some apicomplexans also have a conoid, which is thought to aid mechanics during attachment and invasion of the host cell (Morrissette & Sibley, 2002). Conoids have been visualized in the fish haemogregarines *Haemogregarina sachai* and *Haemogregarina simondi*, although it is unknown whether all *Haemogregarina* have this feature (Kirmse, 1979). Both the rhoptries and micronemes are secretory organelles which help with attachment and invasion of the host cell (Morrissette & Sibley, 2002). The parasitophorous vacuole is an invasion apparatus, whose functions slightly alter depending on the developmental stage the parasite is in (Beyer et al., 2002). Invasion into the host blood cell is mediated by three organelles associated with the parasitophorous vacuole; micronemes, rhoptries, and dense granules (Beyer et al., 2002; Mercier et al., 2005) secretions given off by these organelles are responsible for the formation of the parasitophorous vacuole and help mediate the invasion process (Beyer et al., 2002). The parasitophorous vacuole invaginates the cell as the parasite enters and later is sealed off (Beyer et al., 2002).

The apical polar ring is a circular microtubule organizing center and is responsible for the organization of the subpellicular microtubules (Morrissette & Sibley, 2002).

These microtubules play a role in cell shape and rigidity via the subpellicular network that lies within the parasite (Morrissette & Sibley, 2002). The other type of microtubule present in the Apicomplexa are the spindle microtubules, which are seen during mitosis in replicating parasites (Morrissette & Sibley, 2002). These microtubules are organized by spindle pole plaques, which along with the apical polar ring are organized by the cell centriole (Morrissette & Sibley, 2002). Having multiple microtubule organizing centers allows for increased cell flexibility and control of nuclear division (Morrissette & Sibley, 2002). During this division, there is no breakdown of the nuclear membrane (Morrissette & Sibley, 2002).

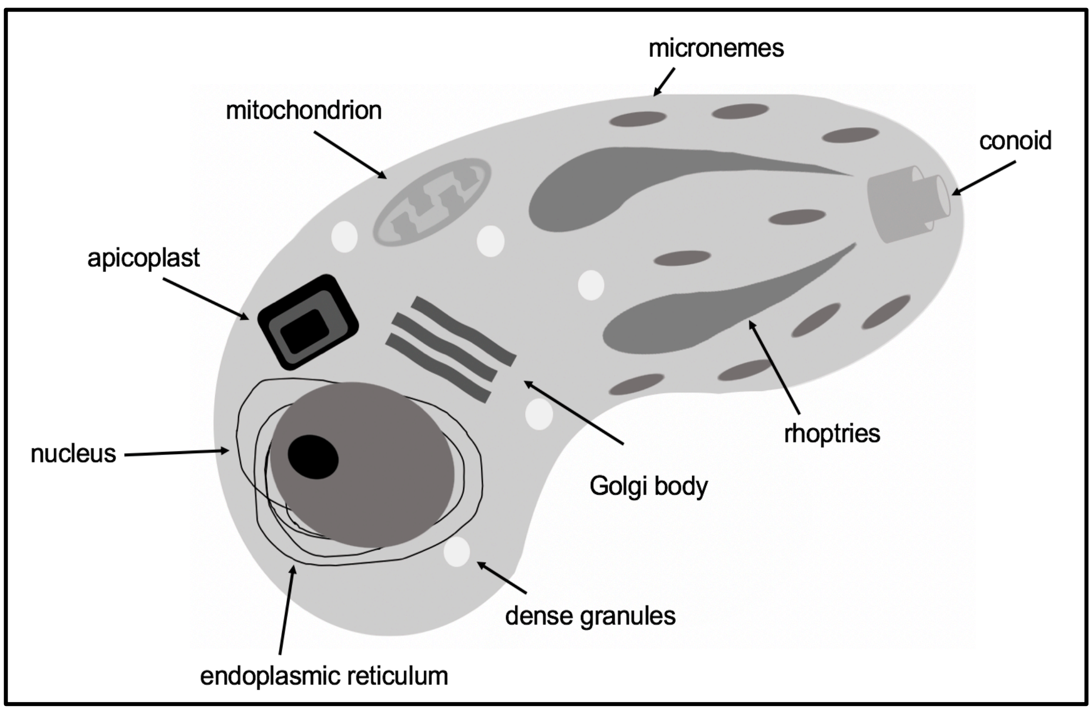

Figure 2: General morphology for an apicomplexan parasite. Includes unique apicomplexan organelles such as the apical polar ring, micronemes, and rhoptries.

Haemogregarina requires two hosts in order to complete their life cycle. Complete life cycles have been observed and recorded for two species, *H. stepanowi* and

H. balli (Alhaboudi et al., 2017). Sexual development and sporogony occur in the invertebrate host, the leech (Morrissette & Sibley, 2002). Merogony and gamogony occur in the vertebrate host, the turtle (Morrissette & Sibley, 2002) During feeding, the leech ingests gamonts that were formed in the erythrocytes of the turtle (Kirmse, 1979). Male gamonts are termed microgamonts, while female gamonts are termed macrogamonts (Morrissette & Sibley, 2002). The microgamonts are flagellated, enabling them to swim to the macrogamonts for fertilization, which produces a diploid zygote (Morrissette & Sibley, 2002). This diploid zygote then undergoes meiosis in order to re-establish the haploid form that is dominant in this parasite (Morrissette & Sibley, 2002). A monosporoblastic oocyst is formed in the intestinal epithelial cells of the leech, where merogony occurs and results in the formation of merozoites (Davies et al., 2004).

Merogony is a form of asexual reproduction, and Apicomplexans can replicate asexually by either endodyogeny or schizogeny (Morrissette & Sibley, 2002). Endodyogeny results in two daughter cells, whereas schizogeny results in multiple daughter cells (Morrissette & Sibley, 2002). Merozoites invade the leech proboscis, the sucking organ of the leech (Davies et al., 2004). When the leech feeds on turtle blood, the turtle becomes infected with these merozoites. Merogony occurs in the liver, lungs, and spleen of the turtle, followed by more merogony stages in the erythrocytes of the turtles (Davies et al., 2004). This second round of merogony in the turtles leads to the formation of gamonts, which completes the life cycle (Davies et al., 2004).

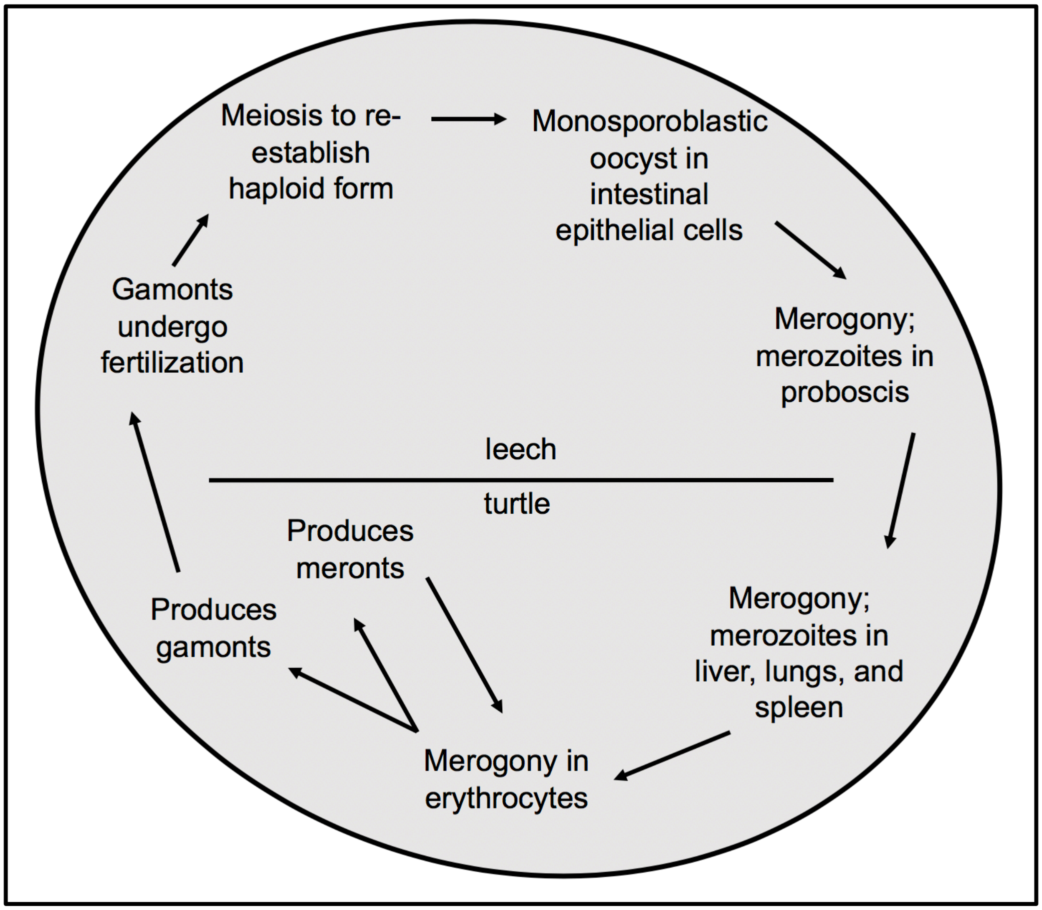

Figure 3: Life cycle stages of a *Haemogregarina balli*. Shows both the invertebrate and vertebrate hosts. Stages occurring in the leech include sexual development, sporogony, and merogony. Stages occurring in the turtle include merogony and gamogony.

Previous studies on these samples allow for a comparison between prevalence and parasite identification determined by both morphological and molecular tools. Prevalence and parasitemia were calculated by analyzing thin blood smears (Lobban, 2003). Turtle blood samples were obtained from the femoral artery or vein, made according to CDC protocol and examined microscopically. Blood smear analysis revealed a low level of parasitaemia among infected turtles. Diagnoses based on morphology, where measurements and any morphological characteristics were recorded, were determined to be either *Haemogregarina* or *Hepatozoon* (Lobban, 2003). Because of the general belief that *Haemogregarina* are transmitted primarily by leeches, and *Hepatozoon* are transmitted primarily by ticks, the blood parasites detected were identified as *Haemogregarina* (Lobban, 2003). Turtles were previously sampled from eight different locations, two captive locations and six wild locations (figure 4; Appendix

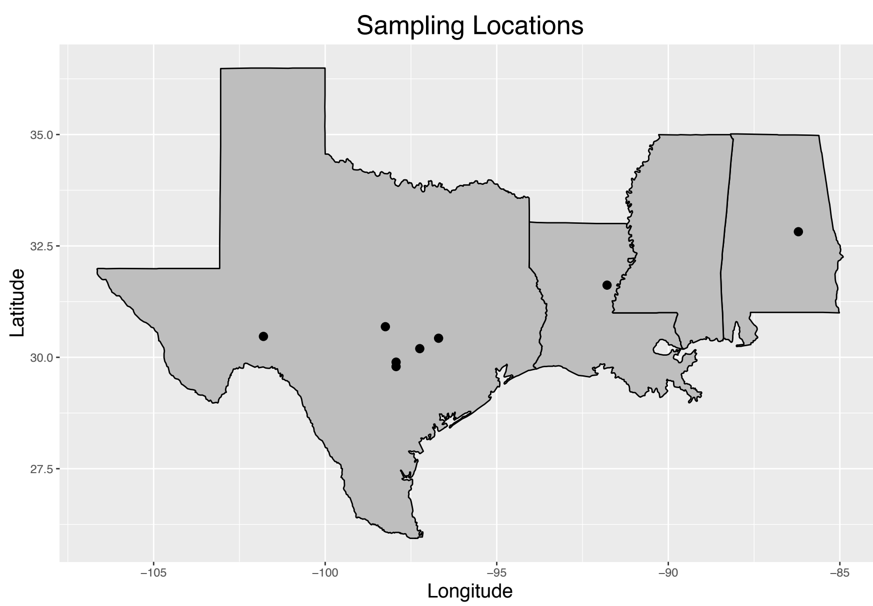

Figure 4: GPS map of sampling locations. Data circles show the eight different locations where turtles were sampled. All wild locations were in Texas, while Concordia Turtle Farm and Guthrie Turtle Farm were in Louisiana and Alabama, respectively.

B). Measurements from each turtle recorded include plastron and carapace length and width, and weight in grams (Appendix H).

PCR was performed on some of the samples that were positive for parasitic infection, based on blood slide examinations. Out of the 110 samples that were amplified with PCR, 37 samples were confirmed to have parasites (Lobban, 2003). However, not all of the samples that had positive results based on blood slide examinations were tested with PCR. Because of this, there are likely more positive samples than originally determined. Since *Haemogregarina* typically exhibit low levels of parasitemia, it is possible that an infection present in a sample was not visualized microscopically.

II. GOAL OF THE STUDY

The goal of our study was to re-analyze all samples available from Lobban (2003) using molecular tools that allowed (1) the detection of infections of turtles with blood parasites, (2) the identification of the blood parasites as belonging to the family Haemogregarinidae, and (3) the identification of these parasites to specific genera within the family Haemogregarinidae. For these goals, DNA segments in extracts from whole blood samples were amplified using quantitative polymerase chain reaction (*q*PCR) to determine the presence/absence of these parasites. *q*PCR is used for this step because of the increased sensitivity compared to end-point PCR, which allows for very small amounts of DNA to be detected. Samples with a positive amplification during *q*PCR were further analyzed by end-point PCR to generate templates for sequence analyses by Sanger protocols. Sequences were assembled in Geneious 9.1.4 (Biomatters Ltd, Auckland, New Zealand), and checked in GenBank/EMBL databases using the BLAST algorithm.

III. MATERIALS AND METHODS

DNA extraction

DNA extraction followed a protocol for nucleated blood cells, (Qiagen DNeasy Blood and Tissue Kit; Qiagen, Hilden, Germany) in which 5-10 µL of blood was added to 20 µL of Proteinase K in a microcentrifuge tube. Volumes were adjusted to 220 µL, adding 190-215 µL of PBS. After addition of PBS, 200 µL of Buffer AL was added to each tube, then vortexed and placed on a shaking incubator set to 56°C for 10 minutes. Following the incubation period, 200 µL of 96-100% ethanol was added to each sample, and vortexed. The total volume was transferred to a DNeasy mini spin column (provided in the kit) and centrifuged at 8,000 rpm for 1 minute. Flow through was discarded, and 500 µL of Buffer AW1 added. Samples were centrifuged at 8,000 rpm for 1 minute, with flow through discarded before adding 500 µL of Buffer AW2. Samples were centrifuged at 13,200 rpm for 3 minutes. Flow through was discarded, and the spin columns were transferred to new microcentrifuge tubes. For the elution step, 100 µL of Buffer AE was added directly onto each membrane. After incubation at room temperature for 1 minute, columns were centrifuged at 8,000 rpm for 1 minute. Another 100 µL of Buffer AE was added, incubated for 1 minute, and the columns centrifuged. Eluted samples were stored at -80°C for long-term storage.

***q*PCR**

Extracted DNA from each sample was analyzed by *q*PCR to check for the presence of Haemogregarinidae parasites. Sybr Green-based analyses were carried out in triplicate in a total volume of 10 µl containing 5 µl SsoADV SybrGreen Mix (BioRad, Hercules, CA), 0.15 µl each of primers JM4F (5'-ACT CAC CAG GTC CAG ACA TAG A-3') and JM5R (5'-CTC AAA CTT CCT TGC GTT AGA C-3') (Maia et al., 2014) targeting 18S rRNA gene sequences (100 nM each), 1 µl of DNA template and 3.7 µl Nuclease Free H_2O in an Eco Real-time PCR system (Illumina, San Diego, CA). Initial incubations at 50°C for 2 minutes and 95°C for 10 minutes were followed by 40 cycles of 95°C for 10 seconds, 64°C for 30 seconds and 72°C for 20 seconds. The amplification was followed by a melting curve analysis. Each *q*PCR included 6 standard dilutions, positive and negative controls, all with two replicates, as well as unknown samples, all with 3 replicates.

Standards were prepared from PCR products of DNA extracted from sample 5810 obtained after amplification with primers JM4F and JM5R. Concentrations of amplicons were measured with a Qubit® 2.0 Fluorometer (Life Technologies, Carlsbad, USA). Copy numbers were obtained using URI Genomics and Sequencing Center's online calculator for determining the number of copies of a template (http://cels.uri.edu/gsc/cndna.html), using the measured concentration for sample 5810 (3.06 ng/µl) and the fragment length (215 bp). Standards were prepared for 10-fold dilutions covering the range from 10^6 - 10^1 copies.

Sequence analyses

Samples showing amplicons after *q*PCR analysis with primers JM4F and JM5R were used for additional PCR-based analyses. These PCR procedures used a larger volume of sample and PCR reaction to obtain sufficient amplification product for sequencing. Each positive sample was amplified with the JM4F/JM5R primer set (215 bp), but also with primers HepF300 (5' – CAA ATC TAA GAA TTT CAC CTC TGA C – 3') and HepR900 (5' – GTT TCT GAC CTA TCA GCT TTC GAC G – 3') (Vilcins et al., 2009) to create a longer fragment of the 18S rRNA gene (633 bp).

For the HepF300/ HepR900 primer set, the PCR protocol was adapted from Maia et al. (2014), with a reduction of the annealing temperature from 63°C to 50°C. The PCR was performed in a final volume of 25 µl, containing 3 µl of sample DNA, 0.5 µl dNTPs, 2.5 µl buffer, 18.875 µl Nuclease-Free H_2O, 0.5 µL of each primer, and 0.125 µL Taq polymerase. PCR conditions consisted of an initial incubation at 95°C for 10 minutes, followed by 35 cycles at 95°C for 10 seconds, 50°C for 30 seconds, and 72°C for 45 seconds, followed by a final incubation at 72°C for 7 minutes.

PCR products (5 µl, mixed with 1 µL of 20x Gel Red), were analyzed by gel electrophoresis (2% agarose gel in 1x TAE buffer). Amplicons were visualized using a BioRad GelDoc EZ Imager. Amplicons were cleaned using Shrimp Alkaline Phosphatase and Exonuclease I (Affymetrix, Santa Clara, CA) following the manufacturer's protocols, and then sequenced bidirectionally using BigDye Terminator v3.1 (Applied Biosystems, Foster City, CA), with the same primers used for PCR. Products were purified by Sephadex G-50 gel filtration before sample plates were loaded onto the ABI-3500

Sequencer (ThermoFisher Scientific, Waltham, MA, USA). Resulting sequences were assembled in Geneious 9.1.4 (Biomatters Ltd, Auckland, New Zealand).

Amplification products that could not be sequenced successfully by direct sequencing attempts were cloned using the TOPO TA Cloning Kit for Sequencing (Invitrogen, Carlsbad, CA, USA) following the manufacture's protocols. The protocol required 0.5 – 4 µl of fresh PCR product, 1 µl of a salt solution, 1 µl of the TOPO vector, with water added to a final volume of 6 µl. The components were mixed, incubated for 15 minutes at room temperature and then placed on ice. For the transformation step, the One Shot TOPO reaction for chemically competent cells protocol was followed. To begin, 2 µl of the TOPO cloning reaction was added to each sample and incubated on ice for 15 minutes. Cells were heat-shocked for 30 seconds in a water bath set to 42°C, and then kept on ice. After cooling, 250 µl of LB broth solution was added to each tube, and samples then incubated in a shaker at 37°C for 2 hours. Each sample had 25 µl plated onto LB plates, supplemented with Ampicillin (50 µg/ml), and cells grown overnight at 37°C. For each sample, 10 colonies were picked, dispersed in 100 µl of water, and cells lysed by incubation for 5 minutes at 100°C. Subsamples of cell lysates were analyzed by PCR with the respective primer set for the presence of a specific amplicon. Cloned amplicons were then amplified using T3/T7 primers, the amplicons purified and sequenced as described above.

The resulting sequences were assembled in Geneious 9.1.4 (Biomatters Ltd, Auckland, New Zealand), and compared against sequences in the GenBank/EMBL databases using the BLAST algorithm. Representative sequences from confirmed Haemogregarinidae were added from the GenBank/EMBL databases and aligned by the

Geneious alignment tool. The identity and relationship among the sequences amplified were evaluated using neighbor joining (NJ) analyses, conducted from within Geneious 9.1.4. Preliminary Neighbor-Joining trees generated with the Geneious Tree Builder (Genetic distance model: HKY) were sorted by topology set at a 99% topology threshold. Trees were resampled using Bootstrap methods for 10,000 replicates.

Statistical analysis

Much of these data were non-numeric and could not be transformed for normality. Data such as prevalence levels related to turtle family were therefore tested using Kruskal-Wallis ANOVA and Dunn's Multiple Comparison Test, as prevalence is considered as a proxy for host specificity (Maia, Carranza, et al., 2016; Mansfield & Mills, 2004). Parasitemia and turtle measurement correlations were tested with Spearman's Rank correlation. Correlations were also evaluated for infection relating to species and infection relating to location. All statistical analyses were completed in R version 3.5.2 as implemented through R studio (version 1.1.463).

IV. RESULTS

Melting curve analysis displayed a single peak between 81.3°C -81.6°C. Fluorescence of the 10^6 copy standards was detectable around cycle 14, with tested samples detectable around 24-27 cycles. After Spearman's correlation analysis, there were no significant correlations between turtle measurements of plastron length (p-value = 0.3054) and width (p-value = 0.2884), as well as carapace length (p-value = 0.688) and width (p-value = 0.5039), to the percentage of parasitemia recorded.

The presence/absence data shows that the families Chelidae*,* Pelomedusidae*,* and Trionychidae had no positive samples, likely a consequence of very low sample sizes for two of the families but less clearly only sampling bias for Chelidae (Figure 6).

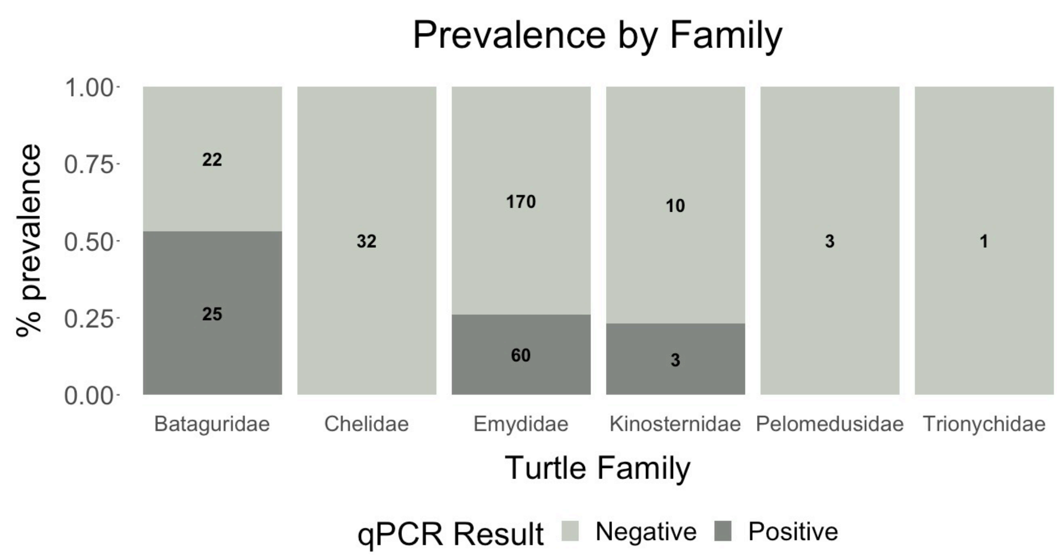

Figure 5: Prevalence of parasitic infection among tested turtle families. Three families, Bataguridae, Emydidae, and Kinosternidae were positive for Haemogregarinidae infections.

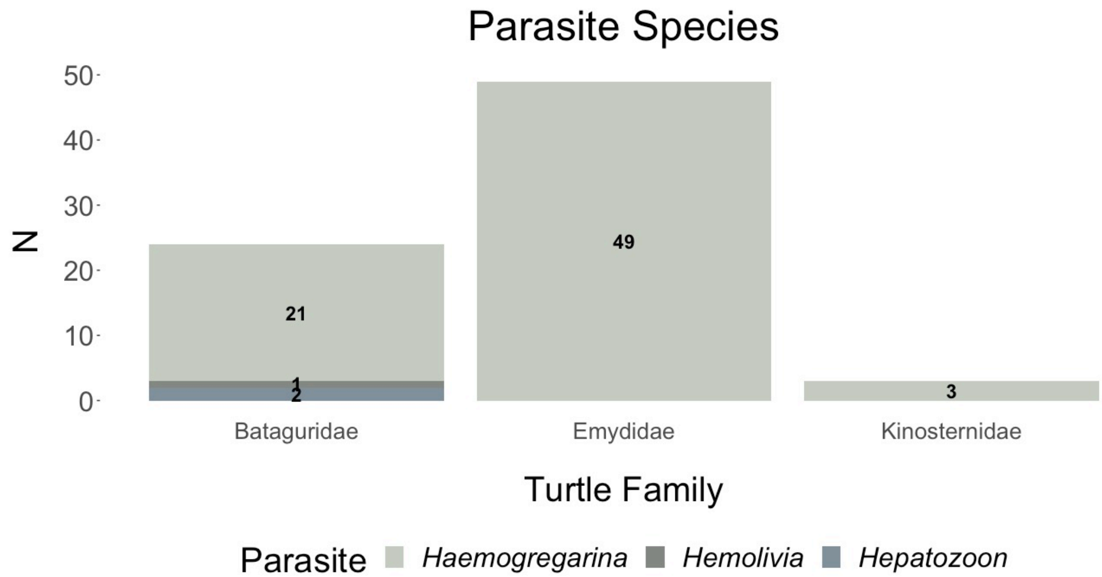

Figure 6: Parasite genera identified in positive turtle families. The family Bataguridae was infected by blood parasites, *Haemogregarina*, *Hepatozoon*, and *Hemolivia*. The Emydidae and Kinosternidae families showed infections by *Haemogregarina* parasites.

Parasitic prevalence in Bataguridae was 53.19% (25/47), 26.08% in Emydidae (60/230) and 23.07% in Kinosternidae (3/13). Using the HepF300/HepR900 primer set, I identified *Haemogregarina* (n=21), *Hepatozoon* (n=2) and *Hemolivia* (n=1) in Bataguridae samples (Figure 6). The Emydidae and Kinosternidae families had *Haemogregarina* infections (n=49, n=3). Using the JM4F/JM5R primer set, I identified *Haemogregarina* and *Hemolivia* infections, however, some samples with parasites could not reliably be assigned either *Haemogregarina, Hepatozoon,* or *Hemolivia*. These samples were therefore described as "inconclusive". The Kruskal-Wallis rank sum test followed by post-hoc analysis with Dunn's test showed a significant difference between infection prevalence in families Bataguridae and Chelidae ($p = 2.68 \times 10^{-6}$), Bataguridae and Emydidae ($p = 1.05 \times 10^{-3}$), and Chelidae and Emydidae ($p = 9.36 \times 10^{-3}$). All other families showed no significant differences between each other.

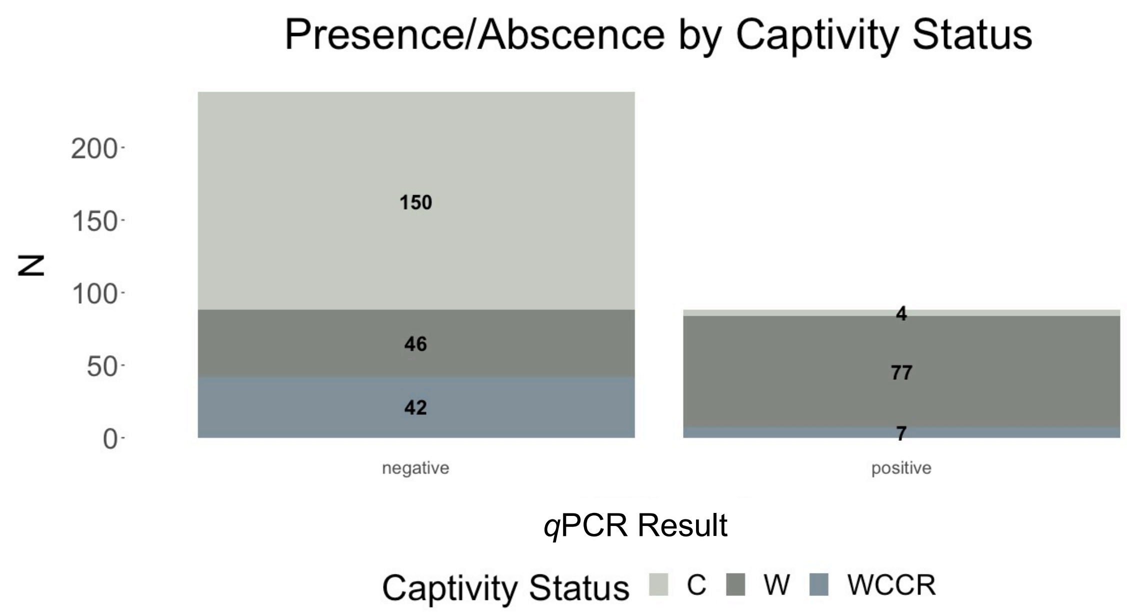

Figure 7: Presence/absence data for each captivity status. Captive (C) were mostly negative for Haemogregarinidae infections, with only four samples positive and a prevalence rate of 2.59%. Wild (W) had a 62.6% prevalence of parasite infections. Wild Caught, Captive Raised turtles had a prevalence of 14.3% with the majority of samples negative for a Haemogregarinidae infection.

Correlations between turtle captivity status show that all categories had samples positive for parasitic infection. In the Wild turtles, 62.6% were positive for infection (n=77), with 2.59% for Captive turtles (n=4), and 14.3% for Wild Caught, Captive Raised turtles (n=7). Sequences were obtained for Wild (n=57) and Wild Caught, Captive Raised (n=6) turtles. The single *Hemolivia* infection was from a WCCR turtle at Guthrie Turtle Farm, where the two *Hepatozoon* infections were also found. Most *Haemogregarina* infections were from Wild turtles. There were significant differences between infection prevalence and Wild versus Captive turtles ($p > 0.001$) and Wild Caught, Captive Raised turtles to Wild turtles ($p > 0.001$).

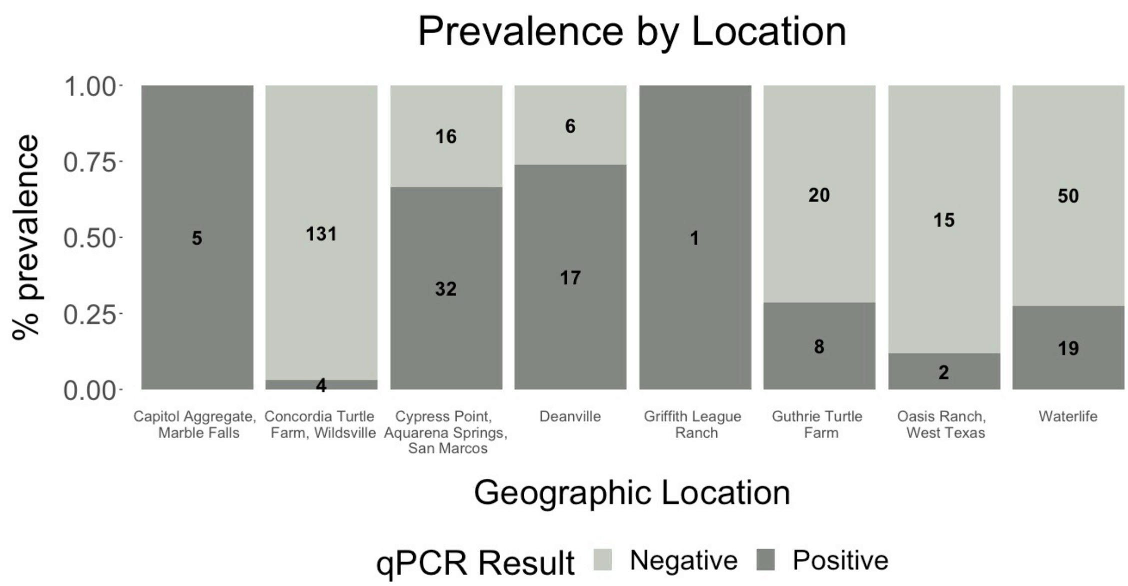

Figure 8: Prevalence of parasitic infection by location. All sampling sites, captive and wild, contained turtles infected with a Haemogregarinidae parasite. Captive locations were Concordia Turtle Farm and Guthrie Turtle Farm.

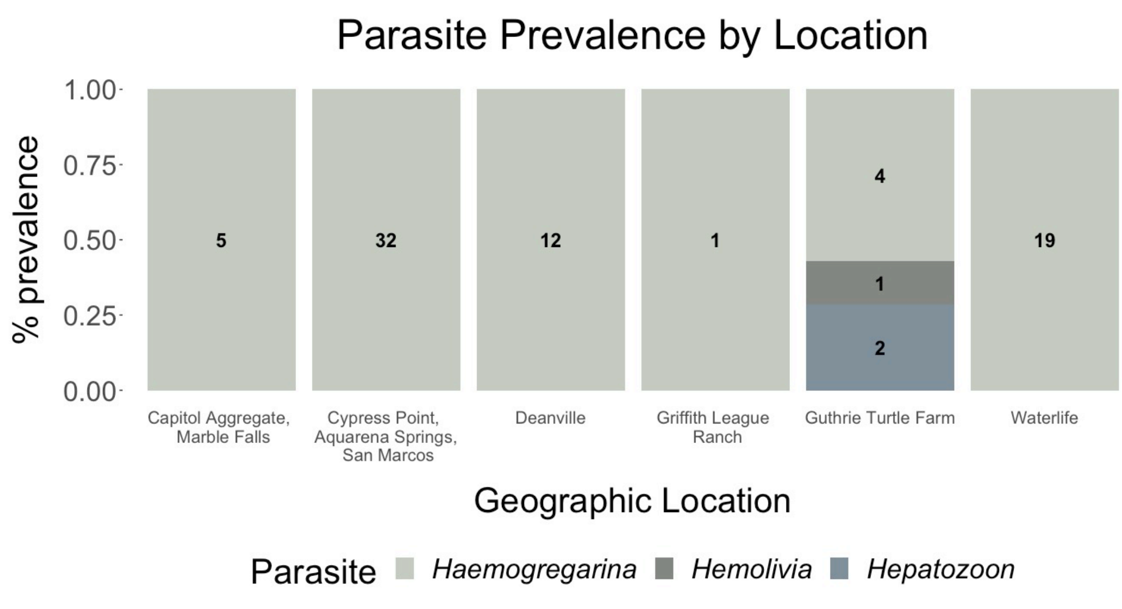

Figure 9: Parasite genera by location. Samples from 5 out of 8 locations were sequenced successfully. The majority of locations had only *Haemogregarina* infections. Guthrie Turtle Farm had *Haemogregarina* infections as well as the only *Hemolivia* and *Hepatozoon* infections.

All eight of the locations had positive samples, with Capitol Aggregate (n=5) and Griffith League Ranch (n=1) having only positive samples (Figure 9). Figure 10 shows locations where samples were successfully sequenced. All five locations had samples that were identified as *Haemogregarina*. The *Hemolivia* and *Hepatozoon* infections at Guthrie Turtle Farm were most likely due to exposure to other turtle species at the turtle farm.

Each sample amplified with the JM4F/JM5R primer set yielded a 215 bp sequence, while those amplified with the HepF300/HepR900 primer set produced a 633 bp amplicon. I was able to sequence 63 samples with the JM4F/JM5R primer set, and 76 samples with the HepF300/HepR900 primer set. Comparative sequence analyses of consensus sequences alignments for both the JM4F/JM5R primer set and HepF300/HepR900 primer set, detected only few base pair differences among the sequences. The sequences generated with the HepF300/HepR900 primer set had 21 base pair differences between *Haemogregarina* and *Hemolivia* samples, while those generated with the JM4F/JM5R primer set had only one bp different between *Haemogregarina* and *Hemolivia* samples. There were other sequence variations found in the alignments, most of which lined up at the same base pair position, with a few isolated differences. There were two differences that were synapomorphies, while most were autapomorphies. Amplicons generated with the JM4F/JM5R primer set consisted of only eight unique sequences while those amplified with the HepF300/HepR900 primer set showed 20 sequence signatures that were isolated occurrence, while 42 signatures occurred at the same location among sequences. There were synapomorphies found at seven nodes, with autapomorphic differences throughout the sequences as well. One of these nodes containing synapomorphies was where the *Hemolivia* samples form a cluster with the *Karyolysus* outgroup.

The use of molecular analysis in this study confirmed presence/absence data of parasites in 262 blood samples previously analyzed by microscopy. However, in 43 of the available blood samples, conflicting results were obtained. *q*PCR-based analysis detected parasites in 16 blood samples, where no parasites had been detected by microscopy. In the remaining 27 samples *q*PCR-based analysis did not detect parasites, even though microscopy had identified parasites in blood samples, with parasitemia values ranging from 0.1-0.38%.

Figure 11 shows a neighbor joining tree generated from sequences obtained from samples amplified with the JM4F/JM5R primer set. Except for sequences from *Hemolivia* samples, there was no differentiation between the remaining sequences. Figure 12 shows a neighbor joining tree generated from samples amplified with the HepF300/HepR900 primer set. There is a clear separation of *Hemolivia* samples from the remaining sequences. The *Hepatozoon* samples are clustering together, with small sequence differences from those of the *Haemogregarinidae* samples. Figure 13 is a neighbor joining tree generated *using cytb* gene regions from GenBank of the turtle species included in this study. There is no correlation between infecting parasite species and turtle host using the sequences gathered from this study.

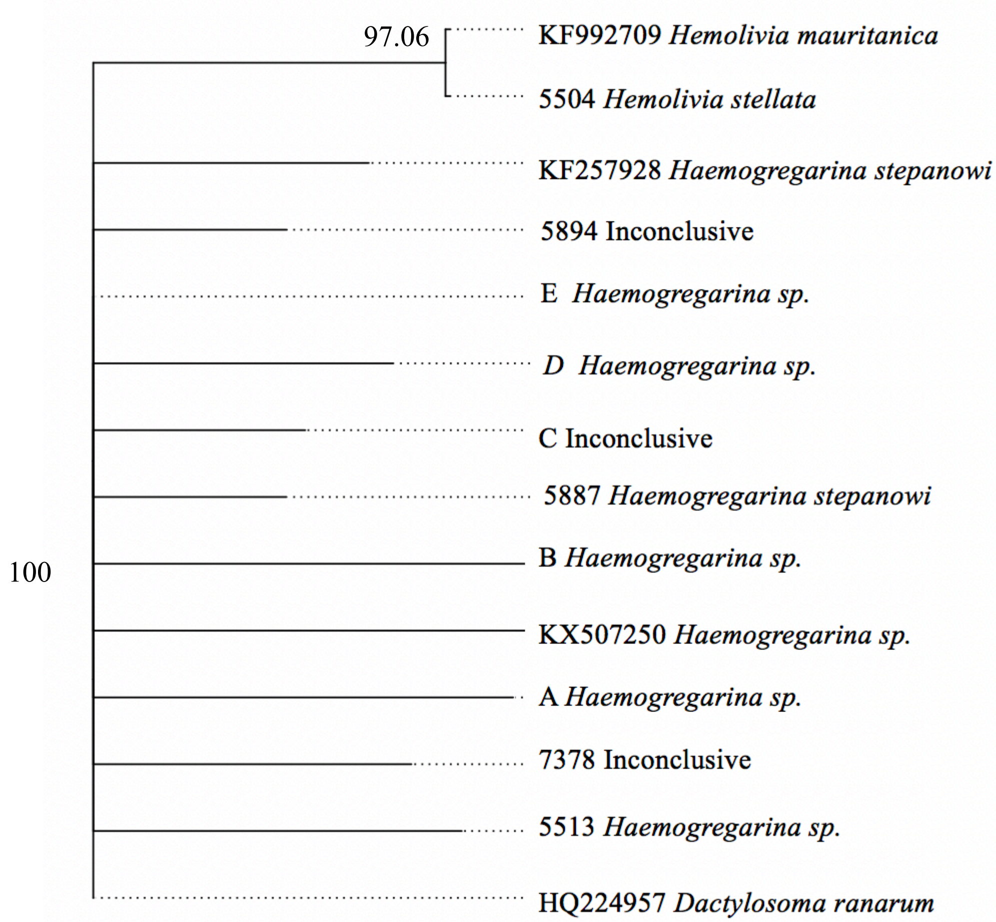

Figure 10 – Neighbor-Joining tree generated in Geneious (version 9.1.7) using JM4F/JM5R primer set sequences. The HKY genetic distance model was used to generate a consensus tree, after 10,000 bootstrap reiterations. Bootstrap values have been reported. Representative samples of replicated sequences are as following: A(5460, 5461, 5462, 5464, 5467, 5469, 5470, 5805, 5807, 5808, 5809, 5810, 5861, 5864, 5865, 5867, 5862, 5818, 5496, 5893, 5895, 5898, 5901, 5903, 5904, 5907, 5511), B(5468, 5499, 5501 5502, 5466, 5463, 5796, 5799, 5857, 5858, 5863, 5886, 5888, 5889, 5802, 5892), C(5829, 5509, 5510, 5820, 5823, 5828, 5831, 5835, 7950, 7951, 5826, 5827), D(5525, 5518, 5523), and E(5822, 5821, 7952, 5828). Inconclusive samples matched to multiple parasite genera with the same percentage of parasitemia, and thus were unable to be identified as one parasite.

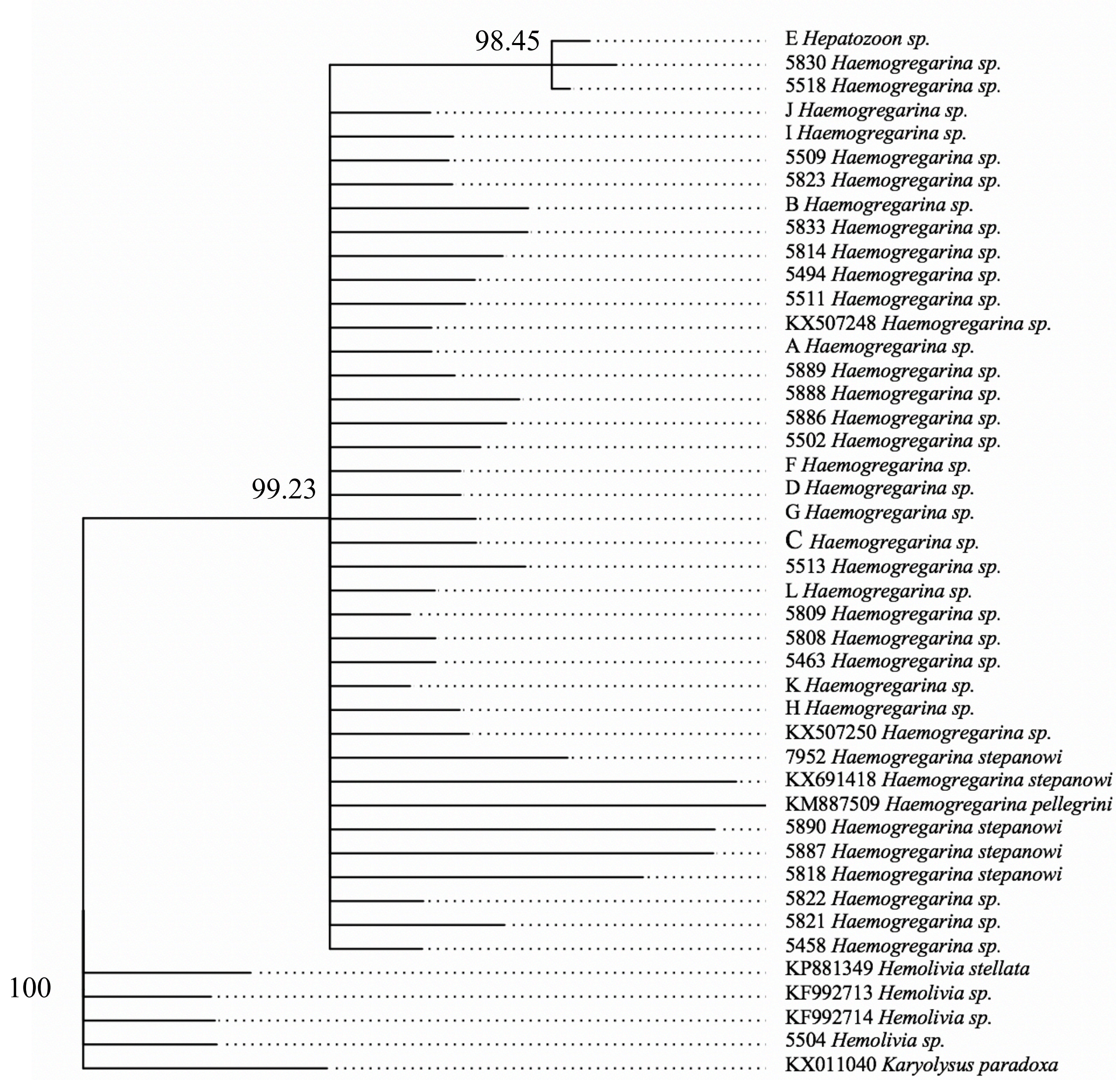

Figure 11 – Neighbor-Joining tree, generated in Geneious (version 9.1.7) using HepF300/HepR900 primer set sequences**.** The HKY genetic distance model was used to generate a consensus tree, after 10,000 bootstrap reiterations. Bootstrap values have been reported. Representative samples of replicated sequences are as following: A(5858, 5862, 5885, 5895, 5903, 5907, 5912, 7378), B(5820, 5831, 5835, 7950, 7951), C(5807, 5893, 5897, 5901), D(5805, 5806, 5861), E(5523, 5525), F(5462, 5470), G(5864, 5865, 5904), H(5468, 5799), I(5826, 5828), J(5829, 5827), K(5460, 5461, 5464, 5466, 5496, 5499, 5501, 5796, 5797, 5802, 5857, 5867, 5889, 5898), and L(5469, 5810).

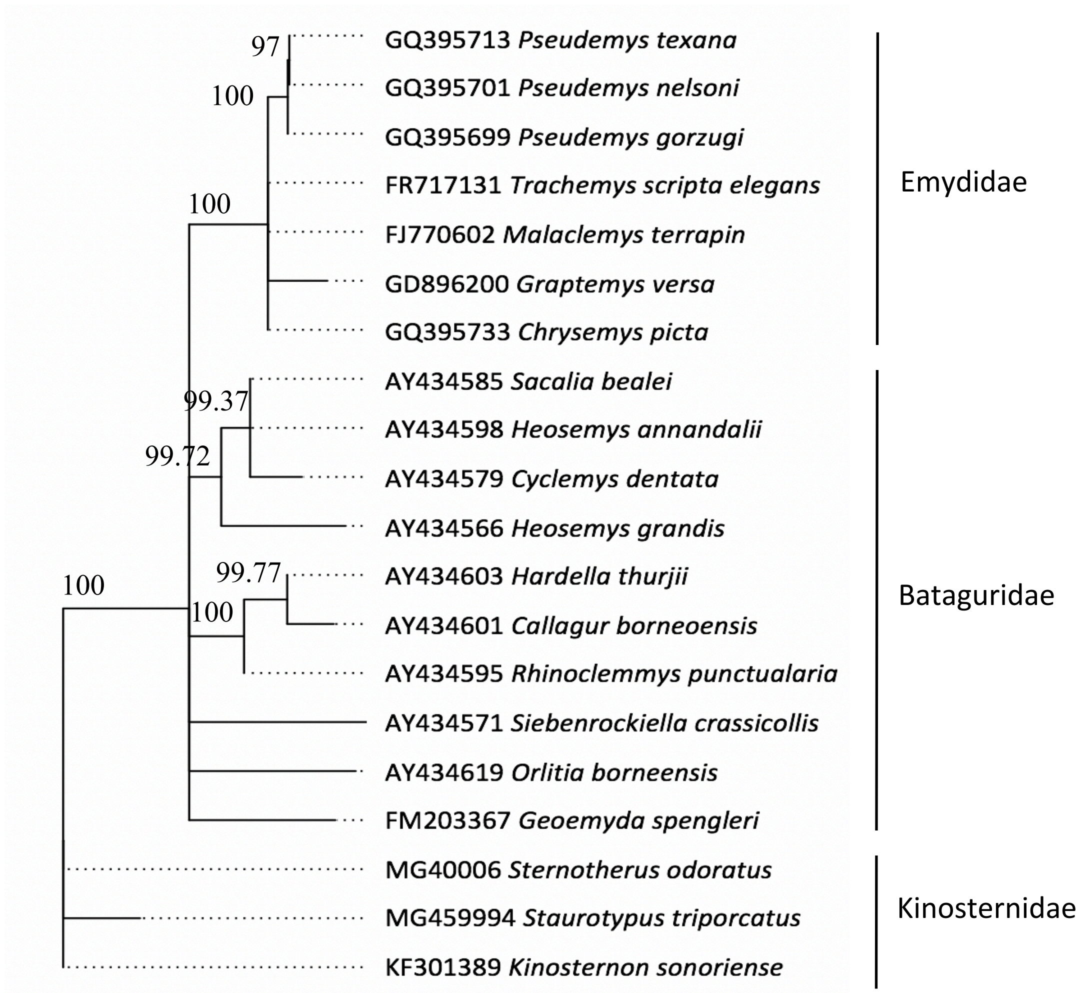

Figure 12 – Neighbor-Joining tree generated in Geneious (version 9.1.7) using sequences obtained from GenBank of turtle species used in this study. Samples include sequences generated using the *cytb* gene as the target region. The HKY genetic distance model was used to generate a consensus tree. The tree was resampled with bootstrap methods for 10,000 replicates. Bootstrap values have been reported.

V. DISCUSSION

This study sought to evaluate the usefulness of molecular diagnostic tests for the detection of blood parasites belonging to the family Haemogregarinidae in turtle species. The majority of results with respect to presence/absence determination was consistent for both microscopy and molecular techniques. There were, however, a few inconclusive results where molecular detection was inconsistent with microscopy detection and *vice versa*; these samples will require additional attention. Low abundance of parasites in blood samples might have impacted detection by microscopy, although *q*PCR was able to detect the parasites after DNA extraction of a larger sample. Samples where *q*PCR failed to detect parasites while microscopy methods detected parasites could have been caused by PCR-inhibiting substances or the presence of parasites not in Haemogregarinidae, with primers failing to anneal. Thus, in order to complete the molecular analysis of parasites in blood samples of different turtle species, additional studies including other blood parasites need to be considered.

The purpose of using molecular tools was to better inform conservation management of turtles; both generally and of the captive management, propagation, and potential reintroduction of captive offspring. I found low prevalence in captive born turtles, likely due to proper leech control such as Copper Sulfate water treatments. A reduction in vectors could have led to a decrease in disease prevalence among captive born turtles. This decrease in prevalence is important especially for those turtles potentially reintroduced to a wild environment, as turtles are highly susceptible to disease as parasitism. Reintroducing turtles with hemogregarine infections could potentially spread this infection to an area previously untouched by these blood parasites.

The majority of parasitic infections found in this study were caused by *Haemogregarina*, with samples also positive for *Hepatozoon* and *Hemolivia.* The differentiation of these parasites from each other required larger sequences (633 bp) generated with the HepF300/HepR900 primer set, compared to the smaller sequences generated with the JM4F/JM5R primer set (215 bp). Since the JM4F/JM5R primer set was used for detection of parasites by *q*PCR, the complete analysis including the detection of parasites in blood samples and their concomitant identification requires separate targets for PCR and sequence analyses.

The low occurrence of positive Haemogregarinidae infections found in captive born turtles show that leech control is successful in captive propagation, but only when health and wellness screenings are strictly followed. Any wild caught turtle that arrives with leeches or ticks should have the ectoparasites removed, and a veterinarian should take a blood sample to check for the presence of a hemogregarine infection (Mikota & Aguilar, 1996). It only takes one vector to spread a blood parasite infection, which may last for many years (Siroky et al., 2004). Farms with outdoor pools should be extra aware of the possibility that a tick or leech vector could be feeding on their turtles, especially for pools where wild caught and captive born turtles are cohabitating. Infected turtles should not be placed with captive born turtles, which are more likely to be free of haemogregarine infections. For captive born turtles that are going to be released to augment declining population sizes, it is imperative that these turtles not have a blood parasite infection before they are placed into a new habitat. All potentially released turtles should have a blood sample examined for blood parasites, to ensure that the release of a novel parasite is not introduced to a new geographic area. Transmission of disease is more prevalent in wild locations, where there is less leech control and a potentially wider variety of vertebrate hosts that may be infected.

The success of leech management can be seen in the low numbers of positive samples found at the Concordia Turtle Farm and Guthrie Turtle Farm, as these locations utilize Copper Sulfate treatments for their water, to reduce the occurrence of leeches and therefore decreasing the rate for probable infection by reducing or eliminating leeches from the holding ponds. This reduction in vectors leads to a reduced prevalence of Haemogregarinidae infections, as *Haemogregarina* infections are not commonly found in captive-bred turtles (Rangel-Mendoza et al., 2009). The four turtles positive for parasites that were captive born at Concordia Turtle Farm were in a dense population, which may result in higher stress and consequently susceptibility for infections. Tick or leech vectors may have been left on a wild caught turtle before it was placed with captive born turtles – this vector could easily spread a hemogregarine infection in stress-compromised turtles. All infected turtles found at Guthrie Turtle Farm were not captive born but wild caught, captive raised. It is possible that these infections occurred before being captured or during transportation. These blood parasites are not well understood although they are commonly found in a wide range of vertebrate hosts, though they are known to have cyclic merogony that can allow for steady levels of parasitemia years after their initial infection (Siroky et al., 2004).

Proper leech control is important given the threats that freshwater turtles face in the environment, leaving them susceptible to a variety of diseases and parasites, such as Haemogregarinidae blood parasites. The habitats favored by freshwater turtles, especially those that are more aquatic than terrestrial, are also habitats where the leech ectoparasite can be found. Based on my results, wild turtles brought to captivity or rescued and placed into conservation programs should undergo thorough health screenings before their use in captive propagation or conservation goals that involve reintroduction to the wild. There are better biosecurity protocols in place at turtle farms for captive propagation, where turtles are more protected from the leech vector; however, taxa are potentially exposed to novel pathogens from differing turtle species, species from other geographic locations, or of individuals that were themselves so exposed prior to arrival at a captive propagation facility.

During this study, there were two turtle families infected by only one parasite genus; Emydidae and Kinosternidae. The Bataguridae family is the only family with detected infections also caused by *Hepatozoon* and *Hemolivia.* This holds true only for identifications made with the HepF300/HepR900 primer set. For the JM4F/JM5R primer set, with many samples inconclusive, it is difficult to confidently claim host specificity. There was not enough differentiation between sequences to resolve the relationship among these parasites, which was supported with phylogenetic analysis. However, with better identification perhaps a larger sample size, a more definitive conclusion can be obtained.

I did not find a correlation between turtle status (Wild, Captive, or Wild Caught, Captive Raised) and percent of parasitemia with specific parasite genera. There was no clear correlation between tree topologies comparing turtle sequences to parasite sequences. This lack of correlation leads to the conclusion that there is no host specificity or co-evolution occurring within this host-parasite relationship. While there may be no strict host specificity found, there seems to at least be a preference in which family of turtle the parasite infects, or is detected in. Other factors such as habitat type may play a role in which families tend to be infected. With the intermediate vector being the leech, turtles that are more aquatic than terrestrial would have a higher chance of contracting disease. Other factors that may play a role in infection rate include basking requirements and tolerance for disturbance (Lambert et al., 2013).

I was able to identify two *Hepatozoon* and one *Hemolivia* infections using partial 18S rRNA gene sequences; however, these identifications are affected by limited sequence information currently available GenBank databases. Sequence data for Haemogregarinidae parasites, especially *Haemogregarina* and *Hemolivia*, is present for a few species only, many of which are short, partial sequences. To provide better identification and differentiation among these three blood parasites, whole genome sequencing of *Haemogregarina* and *Hemolivia* should be attempted to generate more sequence data and better genome coverage.

Further studies should focus not only on the turtle host, but also on the possible vectors, both leeches and ticks. Some studies have found that *Hepatozoon* and *Hemolivia* species utilize the tick vector as well (Kvicerova et al., 2014; Siroky et al., 2004). Knowing the habitat type of each turtle family, as well as the potential vectors they may come into contact with, can help better predict the genera of parasite they are at risk of contracting. Ticks and leeches are both potential problems in captive propagation, as they can spread disease throughout entire farms if precautions are not taken. Because of the role they play in disease transmission, it is important to definitively define the parasites they may harbor – are they polyparasitized, or do they carry only one genus of parasite? It is important to fill this gap of knowledge as the concern of turtle species becoming infected by a novel parasite, and consequently suffering from a more severe reaction, is quite likely given the proper exposure and vectors. Moreover, knowing that these parasitic infections are long-lasting and may occur for years after exposure, it is important to screen each turtle with a blood sample analysis to check for parasitic diseases before reintroducing them into the wild.

APPENDIX SECTION

APPENDIX A

PRIMERS USED

DEVELOPED BY GINA LOBBAN (LOBAN, 2003)

18SF7 5' – CAGTTGGGGGCATTTGTATTTAACTGTCA – 3'

18SR6 5' – ATCTATCCCCATCACGATCGAYA – 3'

HEPATOZOON SPECIFIC (VILCINS ET AL., 2009)

HepF300 5' – GTTTCTGACCTATCAGCTTTCGACG – 3'

HepR900 5' – CAAATCTAAGAATTTCACCTCTGAC – 3'

HEMOGREGARINE SPECIFIC (MAIA ET AL., 2014)

JM4_F 5' – ACTCACCAGGTCCAGACATAGA – 3'

JM5_R 5' – CTCAAACTTCCTTGCGTTAGAC – 3'

APPENDIX B

GPS DATA FOR SAMPLING LOCATIONS

Location	Latitude	Longitude
Concordia Turtle Farm	31.6197	-91.78447
Guthrie Turtle Farm	32.81884	-86.20853
Capitol Aggregate, Marble Falls	30.68727	-98.24571
Cypress Point, Aquarena Springs	29.89152	-97.93315
Deanville	30.42809	-96.69493
Griffith League Ranch	30.19473	-97.24337
Oasis Ranch, West Texas	30.46872	-101.79943
Waterlife	29.79191	-97.93404

APPENDIX C

GENBANK ACCESSIONS USED IN PHYLOGENETIC TREES

Isolate	Host	Locality	GenBank	Reference
Haemogregarina pellegrini	*Platysternon megacephalum*	China	KM887509	Dvorakova et al. 2015
Haemogregarina sp.	*Macrochelys temminckii*	USA	KX507248	Alhaboubi and Holman 2017
Haemogregarina sp.	*Macrochelys temminckii*	USA	KX507250	Alhaboubi and Holman 2017
Haemogregarina stepanowi	*Mauremys leprosa*	Algeria	KF257929	Dvorakova et al. 2013
Haemogregarina stepanowi	*Emys trinacris*	Italy	KX691418	Arizza et al. 2016
Haemogregarina stepanowi	*Emys orbicularis*	Bulgaria	KF257928	Dvorakova et al. 2013
Hemolivia stellata	*Platysternon megacephalum*	China	KM887509	Dvorakova et al. 2015
Hemolivia mauritanica	*Testudo graeca*	Syria	KF992709	Kvicerova et al. 2014
Hemolivia sp.	*Rhinoclemmys pulcherrima*	Nicaragua	KF992714	Kvicerova et al. 2014
Hemolivia sp.	*Rhinoclemmys pulcherrima*	Nicaragua	KF992713	Kvicerova et al. 2014
Hemolivia stellata	*Amblyomma rotundatum*	Brazil	KP881349.1	Karadjian et al. 2015
Karyolysus paradoxa	*Varanus albigularis*	South Africa	KX011040.1	Cook et al. 2016

APPENDIX D

COMPARISON OF PRESENCE/ABSENCE DATA

PCR results are from data generated in Lobban, 2003. *q*PCR results were generated during this current study. Parasitemia values are included, however data is not available for each sample.

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5458	Bataguridae	0.92		positive
5460	Emydidae	0.16	negative	positive
5461	Emydidae	0.21	positive	positive
5462	Emydidae	0.02	positive	positive
5474	Bataguridae	0		negative
5475	Bataguridae	0		negative
5476	Bataguridae	0	negative	negative
5477	Bataguridae	0		negative
5478	Bataguridae	0		negative
5479	Bataguridae	0	negative	negative
5483	Chelidae	0		negative
5484	Emydidae	0	negative	negative
5485	Emydidae	0		negative
5486	Emydidae	0		negative
5487	Emydidae	0		negative
5488	Emydidae		negative	negative
5489	Chelidae	0	negative	negative
5490	Chelidae	0		negative
5491	Chelidae	0	negative	negative
5492	Chelidae	0		negative
5527	Kinosternidae			negative
5528	Kinosternidae	0	negative	negative
5529	Kinosternidae	0	negative	negative
5532	Emydidae	0	negative	negative
5533	Emydidae	0	negative	negative
5534	Emydidae	0	negative	negative
5535	Emydidae	0	negative	negative
5536	Emydidae	0	negative	negative
5537	Emydidae	0		negative
5538	Emydidae	0		negative
5539	Emydidae	0		negative
5540	Emydidae	0		negative
5541	Emydidae	0		negative
5542	Emydidae	0		negative
5543	Emydidae	0		negative
5544	Emydidae	0		negative
5545	Emydidae	0		negative
5552	Emydidae	0		negative
5553	Emydidae	0		negative
5554	Emydidae	0		negative
5555	Emydidae	0		negative
5556	Emydidae	0		negative
5557	Emydidae	0		negative
5558	Emydidae	0		negative

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5559	Emydidae	0		negative
5560	Emydidae	0		negative
5561	Emydidae	0		negative
5562	Emydidae	0		negative
5563	Emydidae	0		negative
5564	Emydidae	0		negative
5565	Emydidae	0		negative
5566	Emydidae	0		negative
5567	Emydidae	0		negative
5568	Emydidae	0		negative
5569	Emydidae	0	negative	negative
5570	Emydidae	0		negative
5571	Emydidae	0		negative
5572	Emydidae	0		negative
5573	Emydidae	0		negative
5574	Emydidae	0		negative
5575	Emydidae	0		negative
5576	Emydidae	0		negative
5577	Emydidae	0		negative
5578	Emydidae	0		negative
5579	Emydidae	0		negative
5580	Emydidae	0		negative
5581	Emydidae	0		negative
5582	Emydidae	0		negative
5583	Emydidae	0		negative
5584	Emydidae	0		negative
5585	Emydidae	0		negative
5586	Emydidae	0		negative
5587	Emydidae	0		negative
5588	Emydidae	0		negative
5589	Emydidae	0		negative
5590	Emydidae	0		negative
5591	Emydidae	0		negative
5592	Emydidae	0		negative
5593	Emydidae	0		negative
5594	Emydidae	0		negative
5595	Emydidae	0		negative
5596	Emydidae	0		negative
5597	Emydidae	0		negative
5598	Emydidae	0		negative
5599	Emydidae	0		negative
5600	Emydidae	0		negative
5601	Emydidae	0		negative
5602	Emydidae	0		negative

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5603	Emydidae	0		negative
5604	Emydidae	0		negative
5605	Emydidae	0		negative
5608	Emydidae	0		negative
5609	Emydidae	0		negative
5610	Emydidae	0		negative
5611	Emydidae	0		negative
5612	Emydidae	0		negative
5613	Emydidae	0		negative
5614	Emydidae	0		negative
5615	Emydidae	0		negative
5616	Emydidae	0		negative
5617	Emydidae	0		negative
5618	Emydidae	0		negative
5619	Emydidae	0		negative
5620	Emydidae	0		negative
5621	Emydidae	0		negative
5622	Emydidae	0		negative
5623	Emydidae	0		negative
5624	Emydidae	0		negative
5625	Emydidae	0		negative
5626	Emydidae	0		negative
5627	Emydidae	0		negative
5628	Emydidae	0		negative
5629	Emydidae	0		negative
5630	Emydidae	0		negative
5631	Emydidae	0		negative
5632	Emydidae	0		negative
5633	Emydidae	0		negative
5634	Emydidae	0		negative
5635	Emydidae	0		negative
5636	Emydidae	0		negative
5637	Emydidae	0		negative
5638	Emydidae	0		negative
5639	Emydidae	0		negative
5640	Emydidae	0		negative
5641	Emydidae	0		negative
5642	Emydidae	0		negative
5643	Emydidae	0		negative
5644	Emydidae	0		negative
5645	Emydidae	0		negative
5646	Emydidae	0		negative
5647	Emydidae	0		negative
5648	Emydidae	0		negative

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5649	Emydidae	0		negative
5650	Emydidae	0		negative
5651	Emydidae	0		negative
5652	Emydidae	0		negative
5653	Emydidae	0		negative
5654	Emydidae	0		negative
5655	Emydidae	0		negative
5657	Emydidae	0		negative
5658	Emydidae	0		negative
5660	Emydidae	0		negative
5661	Emydidae	0		negative
5662	Emydidae	0		negative
5663	Emydidae	0		negative
5664	Emydidae	0		negative
5665	Emydidae	0		negative
5666	Emydidae	0		negative
5667	Emydidae	0		negative
5668	Emydidae	0		negative
5669	Emydidae	0		negative
5670	Emydidae	0		negative
5795	Emydidae	0		negative
5852	Kinosternidae	0		negative
5463	Emydidae	0.01	negative	positive
5464	Emydidae	0.25	negative	positive
5466	Emydidae	0.23	positive	positive
5467	Emydidae	0.15	positive	positive
5468	Emydidae	0.09	positive	positive
5469	Emydidae	0.11	positive	positive
5470	Emydidae	0.2		positive
5494	Bataguridae	0.07	positive	positive
5496	Emydidae	0.08	positive	positive
5499	Emydidae	0.39		positive
5501	Emydidae	0.28		positive
5502	Kinosternidae	0.16	negative	positive
5504	Bataguridae	0	negative	positive
5509	Bataguridae	0.05		positive
5510	Bataguridae	1.75	positive	positive
5511	Kinosternidae	0.62		positive
5513	Kinosternidae	0.03	positive	positive
5518	Bataguridae	0.003	positive	positive
5523	Bataguridae		negative	positive
5525	Bataguridae	0		positive
5606	Emydidae	0		positive
5607	Emydidae	0		positive

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5656	Emydidae	0		positive
5659	Emydidae	0		positive
5796	Emydidae	0.06	positive	positive
5797	Emydidae	0.07		positive
5799	Emydidae	0.039		positive
5802	Emydidae	0.17		positive
5805	Emydidae	0.86	positive	positive
5806	Emydidae	0.21		positive
5807	Emydidae	2	positive	positive
5808	Emydidae	0.03		positive
5809	Emydidae	0	negative	positive
5810	Emydidae	0.63	positive	positive
5814	Bataguridae	0.17	positive	positive
5818	Bataguridae	0.22		positive
5820	Bataguridae	1.14	positive	positive
5821	Bataguridae	0.52		positive
5822	Bataguridae	0.56		positive
5823	Bataguridae	0.15	positive	positive
5826	Bataguridae	0.61	positive	positive
5827	Bataguridae	0.09		positive
5828	Bataguridae	0.1	positive	positive
5829	Bataguridae	2.1	positive	positive
5830	Bataguridae	0.8		positive
5831	Bataguridae	0.08	positive	positive
5833	Bataguridae	0.48		positive
5835	Bataguridae	1.17	positive	positive
5857	Emydidae	0	negative	positive
5858	Emydidae	0	negative	positive
5861	Emydidae	0.29	positive	positive
5862	Emydidae	0.12		positive
5863	Emydidae	0.1		positive
5864	Emydidae	1.67	positive	positive
5865	Emydidae	0.65	positive	positive
5867	Emydidae	0.2		positive
5872	Emydidae	0	negative	positive
5880	Emydidae	0	negative	positive
5885	Emydidae	0	negative	positive
5886	Emydidae	0.01		positive
5887	Emydidae	0.08		positive
5888	Emydidae	0.51	positive	positive
5889	Emydidae	0.09		positive
5890	Emydidae	0.22		positive
5891	Emydidae	0.01		positive
5892	Emydidae	0.56	positive	positive

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5893	Emydidae	0.38	positive	positive
5894	Emydidae	0.22	negative	positive
5895	Emydidae	0.08		positive
5897	Emydidae	0.05		positive
5898	Emydidae	1.88	positive	positive
5899	Emydidae	0.74		positive
5901	Emydidae	0	negative	positive
5903	Emydidae	0.18		positive
5904	Emydidae	0.46		positive
5906	Emydidae	0	negative	positive
5907	Emydidae	0.1		positive
5459	Emydidae	0.11	positive	negative
5465	Emydidae	0.01	negative	negative
5495	Emydidae	0.03	negative	negative
5497	Kinosternidae	0.14	negative	negative
5498	Emydidae	0.1		negative
5500	Emydidae	0.1		negative
5503	Kinosternidae	0.03		negative
5508	Bataguridae	0.01		negative
5798	Emydidae	0.01		negative
5800	Emydidae	0.05		negative
5801	Emydidae	0.04		negative
5803	Emydidae	0.11		negative
5804	Emydidae	0.03		negative
5811	Bataguridae	0.11		negative
5812	Bataguridae	0.12		negative
5813	Bataguridae	0.68		negative
5817	Bataguridae	0.01	negative	negative
5819	Bataguridae	0.13		negative
5832	Bataguridae	0	negative	negative
5834	Bataguridae	0.12		negative
5856	Emydidae	0.13		negative
5859	Emydidae	0.05		negative
5860	Emydidae	0.38		negative
5866	Emydidae	0.21		negative
5868	Emydidae	0		negative
5869	Emydidae	0		negative
5870	Emydidae	0	negative	negative
5871	Emydidae	0		negative
5873	Emydidae	0		negative
5874	Trionychidae	0	negative	negative
5875	Emydidae	0	negative	negative
5876	Emydidae	0		negative
5877	Emydidae	0	negative	negative

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5878	Emydidae	0	negative	negative
5879	Emydidae	0		negative
5881	Emydidae	0		negative
5882	Emydidae	0	negative	negative
5883	Emydidae	0	negative	negative
5884	Emydidae	0		negative
5896	Emydidae	0.02		negative
5900	Emydidae	0.01		negative
5902	Emydidae	0.6		negative
5905	Emydidae	0.05		negative
5908	Emydidae	0		negative
5911	Emydidae	0		negative
5994	Emydidae	0		negative
5909	Emydidae	0		positive
5910	Emydidae	0		positive
5912	Emydidae	0.89		positive
7378	Emydidae	0.08		positive
7950	Bataguridae	0.85		positive
7951	Bataguridae	1.02	positive	positive
7952	Bataguridae	0.64	positive	positive
5472	Chelidae	0	negative	negative
5473	Bataguridae	0	negative	negative
5480	Bataguridae	0	negative	negative
5481	Chelidae	0		negative
5482	Chelidae	0	negative	negative
5493	Bataguridae	0	negative	negative
5505	Bataguridae	0	negative	negative
5506	Bataguridae	0	negative	negative
5507	Pelomedusidae	0	negative	negative
5512	Bataguridae	0	negative	negative
5514	Kinosternidae	0	negative	negative
5515	Kinosternidae	0	negative	negative
5516	Pelomedusidae			negative
5517	Chelidae	0	negative	negative
5519	Pelomedusidae	0	negative	negative
5520	Chelidae	0	negative	negative
5521	Kinosternidae	0	negative	negative
5522	Bataguridae		negative	negative
5524	Chelidae	0		negative
5526	Bataguridae			negative
5530	Chelidae	0	negative	negative
5531	Chelidae	0		negative
5836	Chelidae	0	negative	negative
5837	Chelidae	0		negative

APPENDIX D – COMPARISON OF PRESENCE/ABSENCE DATA

MF Sample Number	Turtle Family	% Parasitemia	PCR Result	*q*PCR Result
5838	Chelidae	0	negative	negative
5839	Chelidae	0		negative
5840	Chelidae	0	negative	negative
5841	Chelidae	0		negative
5842	Chelidae	0	negative	negative
5843	Chelidae	0		negative
5844	Chelidae	0	negative	negative
5845	Chelidae	0		negative
5846	Chelidae	0	negative	negative
5847	Chelidae	0		negative
5848	Chelidae	0	negative	negative
5849	Chelidae	0		negative
5850	Chelidae	0	negative	negative
5851	Kinosternidae	0		negative
5853	Chelidae	0	negative	negative
5854	Chelidae	0		negative
5855	Chelidae	0		negative
5471	Chelidae	0	negative	negative

APPENDIX E

SAMPLE DATA WITH SEQUENCES FROM HEPF300/HEPR900 PRIMER

APPENDIX E – SAMPLE DATA WITH SEQUENCES FROM HEPF300/HEPR900 PRIMER

MF Sample Number	Parasite Genus	Parasite Species	Turtle Family	Turtle Genus	Turtle Species	Turtle Subspecies	% Parasitemia
5458	*Haemogregarina*	*sp.*	Bataguridae	*Siebenrockiella*	*crassicollis*		0.92
5460	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.16
5461	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.21
5462	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.02
5463	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.01
5464	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.25
5466	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.23
5467	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.15
5468	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.09
5469	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.11
5470	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.2
5494	*Haemogregarina*	*sp.*	Bataguridae	*Hardella*	*Thurjii*		0.07
5496	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.08
5499	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*gorzugi*		0.39
5501	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*gorzugi*		0.28
5502	*Haemogregarina*	*sp.*	Kinosternidae	*Sternotherus*	*odoratus*		0.16
5504	*Hemolivia*	*sp.*	Bataguridae	*Rhinoclemmys*	*punctularia*		0
5509	*Haemogregarina*	*sp.*	Bataguridae	*Siebenrockiella*	*crassicollis*		0.05
5511	*Haemogregarina*	*sp.*	Kinosternidae	*Kinosternon*	*sonoriense*		0.62
5513	*Haemogregarina*	*sp.*	Kinosternidae	*Kinosternon*	*sonoriense*		0.03
5518	*Haemogregarina*	*sp.*	Bataguridae	*Cyclemys*	*dentata*		0.003
5523	*Hepatozoon*	*sp.*	Bataguridae	*Sacalia*	*bealeyi*		
5525	*Hepatozoon*	*sp.*	Bataguridae	*Cyclemys*	*dentata*		0
5796	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*nelsoni*		0.06
5797	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.07
5799	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*nelsoni*		0.039
5802	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.17

APPENDIX E – SAMPLE DATA WITH SEQUENCES FROM HEPF300/HEPR900 PRIMER

MF Sample Number	Parasite Genus	Parasite Species	Turtle Family	Turtle Genus	Turtle Species	Turtle Subspecies	% Parasitemia
5805	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.86
5806	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.21
5807	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	2
5808	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.03
5809	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0
5810	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.63
5814	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.17
5818	*Haemogregarina*	*pellegrini*	Bataguridae	*Heosemys*	*grandis*		0.22
5820	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		1.14
5821	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.52
5822	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.5
5823	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.15
5826	*Haemogregarina*	*sp.*	Bataguridae	*Hieremys*	*annandalii*		0.61
5827	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.09
5828	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.1
5829	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		2.1
5830	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.8
5831	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.08
5833	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.48
5835	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		1.17
5857	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0
5858	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0
5861	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.29
5862	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.12
5863	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.1
5864	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	1.67
5865	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.65

APPENDIX E – SAMPLE DATA WITH SEQUENCES FROM HEPF300/HEPR900 PRIMER

MF Sample Number	Parasite Genus	Parasite Species	Turtle Family	Turtle Genus	Turtle Species	Turtle Subspecies	% Parasitemia
5867	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.2
5885	*Haemogregarina*	*sp.*	Emydidae	*Graptemys*	*versa*		0
5886	*Haemogregarina*	*sp.*	Emydidae	*Graptemys*	*versa*		0.01
5887	*Haemogregarina*	*stepanowi*	Emydidae	*Graptemys*	*versa*		0.08
5888	*Haemogregarina*	*sp.*	Emydidae	*Graptemys*	*versa*		0.51
5889	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.09
5890	*Haemogregarina*	*stepanowi*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.22
5893	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.38
5894	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.22
5895	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.08
5897	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.05
5898	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	1.88
5899	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.74
5901	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0
5903	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.18
5904	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.46
5907	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.1
5912	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.89
7378	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.08
7950	*Haemogregarina*	*sp.*	Bataguridae	*Siebenrockiella*	*crassicollis*		0.85
7951	*Haemogregarina*	*sp.*	Bataguridae	*Siebenrockiella*	*crassicollis*		1.02
7952	*Haemogregarina*	*stepanowi*	Bataguridae	*Heosemys*	*grandis*		0.64

APPENDIX F

SAMPLE DATA WITH SEQUENCES FROM JM4F/JM5R PRIMER

APPENDIX F – SAMPLE DATA WITH SEQUENCES FROM JM4F/JM5R PRIMER

MF Sample Number	Parasite Genus	Parasite Species	Turtle Family	Turtle Genus	Turtle Species	Turtle Subspecies	% Parasitemia
5460	Inconclusive		Emydidae	*Pseudemys*	*texana*		0.16
5461	Inconclusive		Emydidae	*Pseudemys*	*texana*		0.21
5462	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.02
5463	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.01
5464	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.25
5466	Inconclusive		Emydidae	*Pseudemys*	*texana*		0.23
5467	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.15
5468	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.09
5469	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.11
5470	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.2
5496	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.08
5499	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*gorzugi*		0.39
5501	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*gorzugi*		0.28
5502	*Haemogregarina*	*sp.*	Kinosternidae	*Sternotherus*	*odoratus*		0.16
5504	*Hemolivia*	*stellata*	Bataguridae	*Rhinoclemmys*	*punctularia*		0
5509	Inconclusive		Bataguridae	*Siebenrockiella*	*crassicollis*		0.05
5510	Inconclusive		Bataguridae	*Siebenrockiella*	*crassicollis*		1.75
5511	*Haemogregarina*	*sp.*	Kinosternidae	*Kinosternon*	*sonoriense*		0.62
5513	*Haemogregarina*	*sp.*	Kinosternidae	*Kinosternon*	*sonoriense*		0.03
5518	Inconclusive		Bataguridae	*Cyclemys*	*dentata*		0.003
5523	Inconclusive		Bataguridae	*Sacalia*	*bealeyi*		
5525	Inconclusive		Bataguridae	*Cyclemys*	*dentata*		0
5796	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*nelsoni*		0.06
5799	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*nelsoni*		0.039
5802	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.17
5805	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.86
5807	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	2

APPENDIX F – SAMPLE DATA WITH SEQUENCES FROM JM4F/JM5R PRIMER

MF Sample Number	Parasite Genus	Parasite Species	Turtle Family	Turtle Genus	Turtle Species	Turtle Subspecies	% Parasitemia
5808	Inconclusive		Emydidae	*Trachemys*	*scripta*	*elegans*	0.03
5809	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0
5810	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0.63
5818	*Haemogregarina*	*sp.*	Bataguridae	*Heosemys*	*grandis*		0.22
5820	Inconclusive		Bataguridae	*Heosemys*	*grandis*		1.14
5821	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.52
5822	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.56
5823	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.15
5828	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.1
5829	Inconclusive		Bataguridae	*Heosemys*	*grandis*		2.1
5831	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.08
5833	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.48
5835	Inconclusive		Bataguridae	*Heosemys*	*grandis*		1.17
5857	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0
5858	*Haemogregarina*	*sp.*	Emydidae	*Pseudemys*	*texana*		0
5861	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.29
5862	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.12
5863	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.1
5864	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	1.67
5865	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.65
5867	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.2
5886	*Haemogregarina*	*sp.*	Emydidae	*Graptemys*	*versa*		0.01
5887	Inconclusive		Emydidae	*Graptemys*	*versa*		0.08
5888	*Haemogregarina*	*sp.*	Emydidae	*Graptemys*	*versa*		0.51
5889	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.09
5893	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.38
5895	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.08

APPENDIX F – SAMPLE DATA WITH SEQUENCES FROM JM4F/JM5R PRIMER

MF Sample Number	Parasite Genus	Parasite Species	Turtle Family	Turtle Genus	Turtle Species	Turtle Subspecies	% Parasitemia
5897	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.05
5898	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	1.88
5901	Inconclusive		Emydidae	*Trachemys*	*scripta*	*elegans*	0
5903	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.18
5904	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.46
5907	*Haemogregarina*	*sp.*	Emydidae	*Trachemys*	*scripta*	*elegans*	0.1
7950	Inconclusive		Bataguridae	*Siebenrockiella*	*crassicollis*		0.85
7951	Inconclusive		Bataguridae	*Siebenrockiella*	*crassicollis*		1.02
7952	Inconclusive		Bataguridae	*Heosemys*	*grandis*		0.64

APPENDIX G

LOCALITY INFORMATION FOR EACH SAMPLE

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5458	Waterlife	W	Bataguridae	*Siebenrockiella*	*crassicollis*	
5460	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5461	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5462	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5474	Waterlife	C	Bataguridae	*Callagur*	*borneoensis*	
5475	Waterlife	C	Bataguridae	*Callagur*	*borneoensis*	
5476	Waterlife	C	Bataguridae	*Callagur*	*borneoensis*	
5477	Waterlife	C	Bataguridae	*Callagur*	*borneoensis*	
5478	Waterlife	C	Bataguridae	*Callagur*	*borneoensis*	
5479	Waterlife	C	Bataguridae	*Callagur*	*borneoensis*	
5483	Waterlife	C	Chelidae	*Chelodina*	*siebenrocki*	
5484	Waterlife	C	Emydidae	*Malaclemys*	*terrapin*	
5485	Waterlife	C	Emydidae	*Malaclemys*	*terrapin*	
5486	Waterlife	C	Emydidae	*Malaclemys*	*terrapin*	
5487	Waterlife	C	Emydidae	*Malaclemys*	*terrapin*	
5488	Waterlife	C	Emydidae	*Graptemys*	*versa*	
5489	Waterlife	C	Chelidae	*Emydura*	*subglobosa*	
5490	Waterlife	C	Chelidae	*Emydura*	*subglobosa*	
5491	Waterlife	C	Chelidae	*Emydura*	*subglobosa*	
5492	Waterlife	C	Chelidae	*Emydura*	*subglobosa*	
5527	Guthrie Turtle Farm	C	Kinosternidae	*Staurotypus*	*triporcatus*	
5528	Guthrie Turtle Farm	C	Kinosternidae	*Staurotypus*	*triporcatus*	
5529	Guthrie Turtle Farm	C	Kinosternidae	*Staurotypus*	*triporcatus*	
5532	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5533	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5534	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5535	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5536	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5537	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5538	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5539	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5540	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5541	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5542	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5543	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5544	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5545	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5552	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5553	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5554	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5555	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5556	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5557	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5558	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5559	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5560	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5561	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5562	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5563	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5564	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5565	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5566	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5567	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5568	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5569	Concordia Turtle Farm, Wildsville	C	Emydidae	*Chrysemys*	*picta*	*belli*
5570	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5571	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5572	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5573	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5574	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5575	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5576	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5577	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5578	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5579	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5580	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5581	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5582	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5583	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5584	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5585	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5586	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5587	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5588	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5589	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5590	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5591	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5592	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5593	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5594	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5595	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5596	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5597	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5598	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5599	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5600	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5601	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5602	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5603	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5604	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5605	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5608	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5609	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5610	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5611	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5612	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5613	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5614	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5615	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5616	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5617	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5618	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5619	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5620	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5621	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5622	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5623	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5624	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5625	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5626	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5627	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5628	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5629	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5630	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5631	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5632	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5633	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5634	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5635	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5636	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5637	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5638	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5639	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5640	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5641	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5642	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5643	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5644	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5645	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5646	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5647	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5648	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5649	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5650	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5651	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5652	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5653	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5654	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5655	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5657	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5658	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5660	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5661	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5662	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5663	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5664	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5665	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5666	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5667	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5668	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5669	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5670	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5795	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5852	Waterlife	C	Kinosternidae	*Staurotypus*	*triporcatus*	

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5463	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5464	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5466	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5467	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5468	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5469	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5470	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5494	Waterlife	WCCR	Bataguridae	*Hardella*	*Thurjii*	
5496	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5499	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*gorzugi*	
5501	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*gorzugi*	
5502	Cypress Point, Aquarena Springs, San Marcos	W	Kinosternidae	*Sternotherus*	*odoratus*	
5504	Guthrie Turtle Farm	WCCR	Bataguridae	*Rhinoclemmys*	*punctularia*	
5509	Guthrie Turtle Farm	W	Bataguridae	*Siebenrockiella*	*crassicollis*	
5510	Guthrie Turtle Farm	W	Bataguridae	*Siebenrockiella*	*crassicollis*	
5511	Guthrie Turtle Farm	WCCR	Kinosternidae	*Kinosternon*	*sonoriense*	
5513	Guthrie Turtle Farm	WCCR	Kinosternidae	*Kinosternon*	*sonoriense*	
5518	Guthrie Turtle Farm	WCCR	Bataguridae	*Cyclemys*	*dentata*	
5523	Guthrie Turtle Farm	WCCR	Bataguridae	*Sacalia*	*bealeyi*	
5525	Guthrie Turtle Farm	WCCR	Bataguridae	*Cyclemys*	*dentata*	
5606	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5607	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5656	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5659	Concordia Turtle Farm, Wildsville	C	Emydidae	*Trachemys*	*scripta*	*elegans*
5796	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*nelsoni*	
5797	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5799	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*nelsoni*	
5802	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5805	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5806	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5807	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5808	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5809	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5810	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5814	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5818	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5820	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5821	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5822	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5823	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5826	Waterlife	W	Bataguridae	*Hieremys*	*annandalii*	
5827	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5828	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5829	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5830	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5831	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5833	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5835	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5857	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5858	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5861	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5862	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5863	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5864	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5865	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5867	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5872	Oasis Ranch, West Texas	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5880	Oasis Ranch, West Texas	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5885	Capitol Aggregate, Marble Falls	W	Emydidae	*Graptemys*	*versa*	
5886	Capitol Aggregate, Marble Falls	W	Emydidae	*Graptemys*	*versa*	
5887	Capitol Aggregate, Marble Falls	W	Emydidae	*Graptemys*	*versa*	
5888	Capitol Aggregate, Marble Falls	W	Emydidae	*Graptemys*	*versa*	
5889	Capitol Aggregate, Marble Falls	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5890	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5891	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5892	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5893	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5894	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5895	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5897	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5898	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5899	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5901	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5903	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5904	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5906	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5907	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5459	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5465	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5495	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5497	Cypress Point, Aquarena Springs, San Marcos	W	Kinosternidae	*Sternotherus*	*odoratus*	
5498	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*gorzugi*	
5500	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*gorzugi*	
5503	Cypress Point, Aquarena Springs, San Marcos	W	Kinosternidae	*Sternotherus*	*odoratus*	
5508	Guthrie Turtle Farm	W	Bataguridae	*Siebenrockiella*	*crassicollis*	
5798	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5800	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5801	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5803	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5804	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5811	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5812	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5813	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5817	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5819	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5832	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5834	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	
5856	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5859	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5860	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5866	Cypress Point, Aquarena Springs, San Marcos	W	Emydidae	*Pseudemys*	*texana*	
5868	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5869	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5870	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5871	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5873	Oasis Ranch, West Texas	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5874	Oasis Ranch, West Texas	W	Trionychidae	*Trionyx (Apalone)*	*spinifera*	
5875	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5876	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5877	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5878	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5879	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5881	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5882	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5883	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5884	Oasis Ranch, West Texas	W	Emydidae	*Pseudemys*	*gorzugi*	
5896	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5900	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5902	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5905	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5908	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5911	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5994	Concordia Turtle Farm, Wildsville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5909	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5910	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
5912	Deanville	W	Emydidae	*Trachemys*	*scripta*	*elegans*
7378	Griffith league ranch	W	Emydidae	*Trachemys*	*scripta*	*elegans*
7950	Waterlife	W	Bataguridae	*Siebenrockiella*	*crassicollis*	
7951	Waterlife	W	Bataguridae	*Siebenrockiella*	*crassicollis*	
7952	Waterlife	W	Bataguridae	*Heosemys*	*grandis*	

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5472	Waterlife	WCCR	Chelidae	*Chelodina*	*mccordi*	
5473	Waterlife	WCCR	Bataguridae	*Callagur*	*borneoensis*	
5480	Waterlife	WCCR	Bataguridae	*Geoemyda*	*nigrican*	
5481	Waterlife	WCCR	Chelidae	*Chelodina*	*mccordi*	
5482	Waterlife	WCCR	Chelidae	*Chelodina*	*siebenrocki*	
5493	Waterlife	WCCR	Bataguridae	*Heosemys*	*grandis*	
5505	Guthrie Turtle Farm	WCCR	Bataguridae	*Siebenrockiella*	*crassicollis*	
5506	Guthrie Turtle Farm	WCCR	Bataguridae	*Siebenrockiella*	*crassicollis*	
5507	Guthrie Turtle Farm	WCCR	Pelomedusidae	*Pelusios*	*subniger*	
5512	Guthrie Turtle Farm	WCCR	Bataguridae	*Cyclemys*	*dentata*	
5514	Guthrie Turtle Farm	WCCR	Kinosternidae	*Kinosternon*	*sonoriense*	
5515	Guthrie Turtle Farm	WCCR	Kinosternidae	*Staurotypus*	*triporcatus*	
5516	Guthrie Turtle Farm	WCCR	Pelomedusidae	*Pelusios*	*subniger*	
5517	Guthrie Turtle Farm	WCCR	Chelidae	*Phrynops*	*gibbus*	
5519	Guthrie Turtle Farm	WCCR	Pelomedusidae	*Pelusios*	*subniger*	
5520	Guthrie Turtle Farm	WCCR	Chelidae	*Phrynops*	*gibbus*	
5521	Guthrie Turtle Farm	WCCR	Kinosternidae	*Staurotypus*	*triporcatus*	
5522	Guthrie Turtle Farm	WCCR	Bataguridae	*Sacalia*	*bealeyi*	
5524	Guthrie Turtle Farm	WCCR	Chelidae	*Phrynops*	*gibbus*	
5526	Guthrie Turtle Farm	WCCR	Bataguridae	*Cyclemys*	*dentata*	
5530	Guthrie Turtle Farm	WCCR	Chelidae	*Phrynops*	*platycephala*	
5531	Guthrie Turtle Farm	WCCR	Chelidae	*Phrynops*	*platycephala*	
5836	Waterlife	WCCR	Chelidae	*Chelodina*	*siebenrocki*	
5837	Waterlife	WCCR	Chelidae	*Chelodina*	*siebenrocki*	
5838	Waterlife	WCCR	Chelidae	*Chelodina*	*siebenrocki*	
5839	Waterlife	WCCR	Chelidae	*Chelodina*	*siebenrocki*	

APPENDIX G – LOCALITY INFORMATION FOR EACH SAMPLE

MF Sample Number	Location	W/C/ WCCR	Family	Genus	Species	Subspecies
5840	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5841	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5842	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5843	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5844	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5845	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5846	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5847	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5848	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5849	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5850	Waterlife	WCCR	Chelidae	*Elseya*	*branderhorstii*	
5851	Waterlife	WCCR	Kinosternidae	*Staurotypus*	*triporcatus*	
5853	Waterlife	WCCR	Chelidae	*Phrynops*	*geoffroanus*	
5854	Waterlife	WCCR	Chelidae	*Phrynops*	*geoffroanus*	
5855	Waterlife	WCCR	Chelidae	*Phrynops*	*geoffroanus*	
5471	Waterlife	WCCR	Chelidae	*Emydura*	*subglobosa*	

APPENDIX H

TURTLE MEASUREMENT DATA

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5458	Bataguridae	*Siebenrockiella*	*crassicollis*						1,160
5460	Emydidae	*Pseudemys*	*texana*		181		201	148	800
5461	Emydidae	*Pseudemys*	*texana*		155		178	128	675
5462	Emydidae	*Pseudemys*	*texana*		154		176	134	650
5474	Bataguridae	*Callagur*	*borneoensis*						461
5475	Bataguridae	*Callagur*	*borneoensis*						401
5476	Bataguridae	*Callagur*	*borneoensis*						340
5477	Bataguridae	*Callagur*	*borneoensis*						447
5478	Bataguridae	*Callagur*	*borneoensis*						375
5479	Bataguridae	*Callagur*	*borneoensis*						463
5483	Chelidae	*Chelodina*	*siebenrocki*						279
5484	Emydidae	*Malaclemys*	*terrapin*						533
5485	Emydidae	*Malaclemys*	*terrapin*						315
5486	Emydidae	*Malaclemys*	*terrapin*						353
5487	Emydidae	*Malaclemys*	*terrapin*						273
5488	Emydidae	*Graptemys*	*versa*						235
5489	Chelidae	*Emydura*	*subglobosa*						340
5490	Chelidae	*Emydura*	*subglobosa*						215
5491	Chelidae	*Emydura*	*subglobosa*						286
5492	Chelidae	*Emydura*	*subglobosa*						293
5527	Kinosternidae	*Staurotypus*	*triporcatus*		49	60			80
5528	Kinosternidae	*Staurotypus*	*triporcatus*		82	80			320
5529	Kinosternidae	*Staurotypus*	*triporcatus*		74	71			340

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5532	Emydidae	*Trachemys*	*scripta*	*elegans*	205	134			1,700
5533	Emydidae	*Trachemys*	*scripta*	*elegans*	212	138			1,700
5534	Emydidae	*Trachemys*	*scripta*	*elegans*	180	125			1,200
5535	Emydidae	*Trachemys*	*scripta*	*elegans*	207	131			1,680
5536	Emydidae	*Trachemys*	*scripta*	*elegans*	196	125			1,520
5537	Emydidae	*Trachemys*	*scripta*	*elegans*	214	136			2,180
5538	Emydidae	*Trachemys*	*scripta*	*elegans*	189	126			1,440
5539	Emydidae	*Trachemys*	*scripta*	*elegans*	173	110			1,120
5540	Emydidae	*Trachemys*	*scripta*	*elegans*	208	127			1,820
5541	Emydidae	*Trachemys*	*scripta*	*elegans*	209	138			1,940
5542	Emydidae	*Trachemys*	*scripta*	*elegans*	175	122			1,380
5543	Emydidae	*Trachemys*	*scripta*	*elegans*	177	109			1,060
5544	Emydidae	*Trachemys*	*scripta*	*elegans*	163	110			1,020
5545	Emydidae	*Trachemys*	*scripta*	*elegans*	212	126			1,800
5552	Emydidae	*Trachemys*	*scripta*	*elegans*	106	78			240
5553	Emydidae	*Trachemys*	*scripta*	*elegans*	123	91			320
5554	Emydidae	*Trachemys*	*scripta*	*elegans*	90	77			180
5555	Emydidae	*Trachemys*	*scripta*	*elegans*	102	78			220
5556	Emydidae	*Trachemys*	*scripta*	*elegans*	101	82			220
5557	Emydidae	*Trachemys*	*scripta*	*elegans*	89	69			140
5558	Emydidae	*Trachemys*	*scripta*	*elegans*	99	74			200
5559	Emydidae	*Trachemys*	*scripta*	*elegans*	97	69			180
5560	Emydidae	*Trachemys*	*scripta*	*elegans*	93	68			180

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5561	Emydidae	*Trachemys*	*scripta*	*elegans*	82	63			140
5562	Emydidae	*Trachemys*	*scripta*	*elegans*	96	72			180
5563	Emydidae	*Trachemys*	*scripta*	*elegans*	81	66			140
5564	Emydidae	*Trachemys*	*scripta*	*elegans*	83	61			100
5565	Emydidae	*Trachemys*	*scripta*	*elegans*	77	62			100
5566	Emydidae	*Trachemys*	*scripta*	*elegans*	79	59			100
5567	Emydidae	*Trachemys*	*scripta*	*elegans*	84	65			140
5568	Emydidae	*Trachemys*	*scripta*	*elegans*	64	49			80
5569	Emydidae	*Chrysemys*	*picta*	*belli*	108	73			200
5570	Emydidae	*Trachemys*	*scripta*	*elegans*	265	163			3,220
5571	Emydidae	*Trachemys*	*scripta*	*elegans*	220	146			2,020
5572	Emydidae	*Trachemys*	*scripta*	*elegans*	241	141			2,560
5573	Emydidae	*Trachemys*	*scripta*	*elegans*	216	133			1,800
5574	Emydidae	*Trachemys*	*scripta*	*elegans*	201	140			1,920
5575	Emydidae	*Trachemys*	*scripta*	*elegans*	211	136			2,000
5576	Emydidae	*Trachemys*	*scripta*	*elegans*	238	142			1,960
5577	Emydidae	*Trachemys*	*scripta*	*elegans*	210	133			1,880
5578	Emydidae	*Trachemys*	*scripta*	*elegans*	209	142			1,900
5579	Emydidae	*Trachemys*	*scripta*	*elegans*	223	131			2,020
5580	Emydidae	*Trachemys*	*scripta*	*elegans*	192	119			1,340
5581	Emydidae	*Trachemys*	*scripta*	*elegans*	201	123			1,580
5582	Emydidae	*Trachemys*	*scripta*	*elegans*	230	145			2,200
5583	Emydidae	*Trachemys*	*scripta*	*elegans*	205	120			1,740

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5584	Emydidae	*Trachemys*	*scripta*	*elegans*	207	128			1,600
5585	Emydidae	*Trachemys*	*scripta*	*elegans*	221	132			2,040
5586	Emydidae	*Trachemys*	*scripta*	*elegans*	192	124			1,300
5587	Emydidae	*Trachemys*	*scripta*	*elegans*	205	131			1,580
5588	Emydidae	*Trachemys*	*scripta*	*elegans*	211	130			1,760
5589	Emydidae	*Trachemys*	*scripta*	*elegans*	239	133			2,280
5590	Emydidae	*Trachemys*	*scripta*	*elegans*	221	143			1,920
5591	Emydidae	*Trachemys*	*scripta*	*elegans*	221	131			1,660
5592	Emydidae	*Trachemys*	*scripta*	*elegans*	215	132			1,880
5593	Emydidae	*Trachemys*	*scripta*	*elegans*	206	143			1,560
5594	Emydidae	*Trachemys*	*scripta*	*elegans*	213	135			1,780
5595	Emydidae	*Trachemys*	*scripta*	*elegans*	215	132			1,560
5596	Emydidae	*Trachemys*	*scripta*	*elegans*	225	142			2,220
5597	Emydidae	*Trachemys*	*scripta*	*elegans*	204	129			1,700
5598	Emydidae	*Trachemys*	*scripta*	*elegans*	229	141			2,160
5599	Emydidae	*Trachemys*	*scripta*	*elegans*	199	119			1,500
5600	Emydidae	*Trachemys*	*scripta*	*elegans*	208	137			2,080
5601	Emydidae	*Trachemys*	*scripta*	*elegans*	203	132			1,660
5602	Emydidae	*Trachemys*	*scripta*	*elegans*	215	131			1,720
5603	Emydidae	*Trachemys*	*scripta*	*elegans*	245	156			2,440
5604	Emydidae	*Trachemys*	*scripta*	*elegans*	221	135			1,900
5605	Emydidae	*Trachemys*	*scripta*	*elegans*	219	137			1,840
5608	Emydidae	*Trachemys*	*scripta*	*elegans*	203	128			1,420

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5609	Emydidae	*Trachemys*	*scripta*	*elegans*	169	98			880
5610	Emydidae	*Trachemys*	*scripta*	*elegans*	184	118			1,180
5611	Emydidae	*Trachemys*	*scripta*	*elegans*	153	88			740
5612	Emydidae	*Trachemys*	*scripta*	*elegans*	192	118			1,580
5613	Emydidae	*Trachemys*	*scripta*	*elegans*	209	131			1,620
5614	Emydidae	*Trachemys*	*scripta*	*elegans*	207	125			1,380
5615	Emydidae	*Trachemys*	*scripta*	*elegans*	209	123			1,880
5616	Emydidae	*Trachemys*	*scripta*	*elegans*	220	138			2,000
5617	Emydidae	*Trachemys*	*scripta*	*elegans*	197	120			1,440
5618	Emydidae	*Trachemys*	*scripta*	*elegans*	214	140			2,002
5619	Emydidae	*Trachemys*	*scripta*	*elegans*	208	127			1,800
5620	Emydidae	*Trachemys*	*scripta*	*elegans*	226	134			2,200
5621	Emydidae	*Trachemys*	*scripta*	*elegans*	209	126			1,700
5622	Emydidae	*Trachemys*	*scripta*	*elegans*	228	139			2,220
5623	Emydidae	*Trachemys*	*scripta*	*elegans*	226	127			2,020
5624	Emydidae	*Trachemys*	*scripta*	*elegans*	177	112			1,080
5625	Emydidae	*Trachemys*	*scripta*	*elegans*	203	136			1,680
5626	Emydidae	*Trachemys*	*scripta*	*elegans*	199	126			1,840
5627	Emydidae	*Trachemys*	*scripta*	*elegans*	191	120			1,400
5628	Emydidae	*Trachemys*	*scripta*	*elegans*	196	126			1,460
5629	Emydidae	*Trachemys*	*scripta*	*elegans*	214	136			2,040
5630	Emydidae	*Trachemys*	*scripta*	*elegans*	253	150			2,880
5631	Emydidae	*Trachemys*	*scripta*	*elegans*	191	123			1,480

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5632	Emydidae	*Trachemys*	*scripta*	*elegans*	193	122			1,420
5633	Emydidae	*Trachemys*	*scripta*	*elegans*	198	140			1,660
5634	Emydidae	*Trachemys*	*scripta*	*elegans*	220	138			1,720
5635	Emydidae	*Trachemys*	*scripta*	*elegans*	242	150			3,180
5636	Emydidae	*Trachemys*	*scripta*	*elegans*	223	136			2,080
5637	Emydidae	*Trachemys*	*scripta*	*elegans*	223	141			2,140
5638	Emydidae	*Trachemys*	*scripta*	*elegans*	216	132			1,780
5639	Emydidae	*Trachemys*	*scripta*	*elegans*	224	139			1,960
5640	Emydidae	*Trachemys*	*scripta*	*elegans*	239	151			2,700
5641	Emydidae	*Trachemys*	*scripta*	*elegans*	203	118			1,420
5642	Emydidae	*Trachemys*	*scripta*	*elegans*	228	133			1,860
5643	Emydidae	*Trachemys*	*scripta*	*elegans*	199	131			1,680
5644	Emydidae	*Trachemys*	*scripta*	*elegans*	213	131			1,880
5645	Emydidae	*Trachemys*	*scripta*	*elegans*	221	136			1,880
5646	Emydidae	*Trachemys*	*scripta*	*elegans*	212	140			2,020
5647	Emydidae	*Trachemys*	*scripta*	*elegans*	208	136			1,620
5648	Emydidae	*Trachemys*	*scripta*	*elegans*	217	141			2,100
5649	Emydidae	*Trachemys*	*scripta*	*elegans*	217	135			1,840
5650	Emydidae	*Trachemys*	*scripta*	*elegans*	214	132			1,700
5651	Emydidae	*Trachemys*	*scripta*	*elegans*	200	125			1,400
5652	Emydidae	*Trachemys*	*scripta*	*elegans*	111	76			240
5653	Emydidae	*Trachemys*	*scripta*	*elegans*	119	85			320
5654	Emydidae	*Trachemys*	*scripta*	*elegans*	130	84			360

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5655	Emydidae	*Trachemys*	*scripta*	*elegans*	117	80			300
5657	Emydidae	*Trachemys*	*scripta*	*elegans*	121	82			
5658	Emydidae	*Trachemys*	*scripta*	*elegans*	125	82			340
5660	Emydidae	*Trachemys*	*scripta*	*elegans*	120	82			320
5661	Emydidae	*Trachemys*	*scripta*	*elegans*	106	78			240
5662	Emydidae	*Trachemys*	*scripta*	*elegans*	99	75			160
5663	Emydidae	*Trachemys*	*scripta*	*elegans*	111	83			280
5664	Emydidae	*Trachemys*	*scripta*	*elegans*	110	79			240
5665	Emydidae	*Trachemys*	*scripta*	*elegans*	87	65			140
5666	Emydidae	*Trachemys*	*scripta*	*elegans*	102	75			200
5667	Emydidae	*Trachemys*	*scripta*	*elegans*	98	70			160
5668	Emydidae	*Trachemys*	*scripta*	*elegans*	65	52			60
5669	Emydidae	*Trachemys*	*scripta*	*elegans*	93	70			160
5670	Emydidae	*Trachemys*	*scripta*	*elegans*	80	62			120
5795	Emydidae	*Trachemys*	*scripta*	*elegans*	650	520			60
5852	Kinosternidae	*Staurotypus*	*triporcatus*						1,480
5463	Emydidae	*Pseudemys*	*texana*		151		175	135	625
5464	Emydidae	*Pseudemys*	*texana*		150		177	131	575
5466	Emydidae	*Pseudemys*	*texana*		181		210	155	1,050
5467	Emydidae	*Pseudemys*	*texana*		183		213	158	1,200
5468	Emydidae	*Pseudemys*	*texana*		146		177	127	575
5469	Emydidae	*Pseudemys*	*texana*		149		165	130	600
5470	Emydidae	*Trachemys*	*scripta*	*elegans*	143		145	120	550

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5494	Bataguridae	*Hardella*	*Thurjii*						453
5496	Emydidae	*Pseudemys*	*texana*		250		274	204	
5499	Emydidae	*Pseudemys*	*gorzugi*		206		243	177	1,650
5501	Emydidae	*Pseudemys*	*gorzugi*		141		168	125	525
5502	Kinosternidae	*Sternotherus*	*odoratus*						
5504	Bataguridae	*Rhinoclemmys*	*punctularia*		140	110			760
5509	Bataguridae	*Siebenrockiella*	*crassicollis*		153	115			840
5510	Bataguridae	*Siebenrockiella*	*crassicollis*		134	113			700
5511	Kinosternidae	*Kinosternon*	*sonoriense*		115	59			260
5513	Kinosternidae	*Kinosternon*	*sonoriense*		112	57			260
5518	Bataguridae	*Cyclemys*	*dentata*		148	103			520
5523	Bataguridae	*Sacalia*	*bealeyi*		128	82			260
5525	Bataguridae	*Cyclemys*	*dentata*		156	111			640
5606	Emydidae	*Trachemys*	*scripta*	*elegans*	211	133			1,900
5607	Emydidae	*Trachemys*	*scripta*	*elegans*	239	139			2,400
5656	Emydidae	*Trachemys*	*scripta*	*elegans*	123	86			340
5659	Emydidae	*Trachemys*	*scripta*	*elegans*	102	72			220
5796	Emydidae	*Pseudemys*	*nelsoni*		207		218	175	1,300
5797	Emydidae	*Pseudemys*	*texana*		187		225	167	1,350
5799	Emydidae	*Pseudemys*	*nelsoni*		149		160	126	700
5802	Emydidae	*Pseudemys*	*texana*		209		233	177	1,750
5805	Emydidae	*Trachemys*	*scripta*	*elegans*	198		213	161	1,450
5806	Emydidae	*Trachemys*	*scripta*	*elegans*					

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5807	Emydidae	*Trachemys*	*scripta*	*elegans*	188		208	158	1,400
5808	Emydidae	*Trachemys*	*scripta*	*elegans*					
5809	Emydidae	*Trachemys*	*scripta*	*elegans*	183		202	152	1,250
5810	Emydidae	*Pseudemys*	*texana*		234		261	190	2,100
5814	Bataguridae	*Heosemys*	*grandis*						2,900
5818	Bataguridae	*Heosemys*	*grandis*						3,860
5820	Bataguridae	*Heosemys*	*grandis*						3,620
5821	Bataguridae	*Heosemys*	*grandis*						3,580
5822	Bataguridae	*Heosemys*	*grandis*						3,440
5823	Bataguridae	*Heosemys*	*grandis*						3,780
5826	Bataguridae	*Hieremys*	*annandalii*						5,780
5827	Bataguridae	*Heosemys*	*grandis*						4,160
5828	Bataguridae	*Heosemys*	*grandis*						4,040
5829	Bataguridae	*Heosemys*	*grandis*						3,540
5830	Bataguridae	*Heosemys*	*grandis*						2,400
5831	Bataguridae	*Heosemys*	*grandis*						2,520
5833	Bataguridae	*Heosemys*	*grandis*						3,040
5835	Bataguridae	*Heosemys*	*grandis*						
5857	Emydidae	*Pseudemys*	*texana*		233		233	176	1,850
5858	Emydidae	*Pseudemys*	*texana*		240		271	212	2,600
5861	Emydidae	*Trachemys*	*scripta*	*elegans*	181		192	139	1,000
5862	Emydidae	*Trachemys*	*scripta*	*elegans*	180		197	155	1,200
5863	Emydidae	*Trachemys*	*scripta*	*elegans*					

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5864	Emydidae	*Trachemys*	*scripta*	*elegans*	185		207	158	1,200
5865	Emydidae	*Trachemys*	*scripta*	*elegans*	204		219	169	1,700
5867	Emydidae	*Trachemys*	*scripta*	*elegans*	123		139	107	375
5872	Emydidae	*Trachemys*	*scripta*	*elegans*	150	100	172	125	660
5880	Emydidae	*Trachemys*	*scripta*	*elegans*	120	100	130	120	8
5885	Emydidae	*Graptemys*	*versa*		158	114	197	149	794
5886	Emydidae	*Graptemys*	*versa*		93	63	111	79	227
5887	Emydidae	*Graptemys*	*versa*		79	52	97	68	113
5888	Emydidae	*Graptemys*	*versa*		81	56	99	74	113
5889	Emydidae	*Trachemys*	*scripta*	*elegans*	240	157	254	200	2,495
5890	Emydidae	*Trachemys*	*scripta*	*elegans*	196	140	216	152	1,021
5891	Emydidae	*Trachemys*	*scripta*	*elegans*	184	127	184	152	794
5892	Emydidae	*Trachemys*	*scripta*	*elegans*	216	140	229	178	1,361
5893	Emydidae	*Trachemys*	*scripta*	*elegans*	178	114	191	140	907
5894	Emydidae	*Trachemys*	*scripta*	*elegans*	146	102	152	127	454
5895	Emydidae	*Trachemys*	*scripta*	*elegans*	165	108	191	140	907
5897	Emydidae	*Trachemys*	*scripta*	*elegans*	203	133	210	59	1,270
5898	Emydidae	*Trachemys*	*scripta*	*elegans*	159	102	165	133	454
5899	Emydidae	*Trachemys*	*scripta*	*elegans*	216	146	229	178	1,814
5901	Emydidae	*Trachemys*	*scripta*	*elegans*	203	121	203	159	1,270
5903	Emydidae	*Trachemys*	*scripta*	*elegans*	159	108	172	133	680
5904	Emydidae	*Trachemys*	*scripta*	*elegans*	165	108	184	133	680
5906	Emydidae	*Trachemys*	*scripta*	*elegans*	140	133	152	127	54

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5907	Emydidae	*Trachemys*	*scripta*	*elegans*	178	121	191	171	907
5459	Emydidae	*Pseudemys*	*texana*		253		289	217	2,800
5465	Emydidae	*Pseudemys*	*texana*		182		211	154	1,100
5495	Emydidae	*Pseudemys*	*texana*		184		217	157	1,000
5497	Kinosternidae	*Sternotherus*	*odoratus*						
5498	Emydidae	*Pseudemys*	*gorzugi*		176		206	156	950
5500	Emydidae	*Pseudemys*	*gorzugi*		169		198	149	850
5503	Kinosternidae	*Sternotherus*	*odoratus*						
5508	Bataguridae	*Siebenrockiella*	*crassicollis*		137	111			740
5798	Emydidae	*Pseudemys*	*texana*		136		154	119	500
5800	Emydidae	*Pseudemys*	*texana*		210		241	171	1,600
5801	Emydidae	*Pseudemys*	*texana*		172		205	147	1,000
5803	Emydidae	*Pseudemys*	*texana*		145		159	123	600
5804	Emydidae	*Pseudemys*	*texana*		210		241	171	1,600
5811	Bataguridae	*Heosemys*	*grandis*						7,500
5812	Bataguridae	*Heosemys*	*grandis*						2,520
5813	Bataguridae	*Heosemys*	*grandis*						1,680
5817	Bataguridae	*Heosemys*	*grandis*						4,660
5819	Bataguridae	*Heosemys*	*grandis*						3,100
5832	Bataguridae	*Heosemys*	*grandis*						3,560
5834	Bataguridae	*Heosemys*	*grandis*						4,420
5856	Emydidae	*Pseudemys*	*texana*		211		230	178	1,600
5859	Emydidae	*Pseudemys*	*texana*		235		256	201	2,700

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5860	Emydidae	*Pseudemys*	*texana*		160		176	136	700
5866	Emydidae	*Pseudemys*	*texana*		226		246	184	2,100
5868	Emydidae	*Pseudemys*	*gorzugi*		210	130	220	162	1,440
5869	Emydidae	*Pseudemys*	*gorzugi*		202	140	246	175	1,840
5870	Emydidae	*Pseudemys*	*gorzugi*		187	118	260	151	1,180
5871	Emydidae	*Pseudemys*	*gorzugi*		236	157	261	196	2,520
5873	Emydidae	*Trachemys*	*scripta*	*elegans*	180	110	240	170	1,040
5874	Trionychidae	*Trionyx (Apalone)*	*spinifera*		130	141	186	142	760
5875	Emydidae	*Pseudemys*	*gorzugi*		268	181	296	260	3,820
5876	Emydidae	*Pseudemys*	*gorzugi*		235	150	264	181	2,600
5877	Emydidae	*Pseudemys*	*gorzugi*		190	132	220	164	1,360
5878	Emydidae	*Pseudemys*	*gorzugi*		155	101	126	132	660
5879	Emydidae	*Pseudemys*	*gorzugi*		168	112	183	142	880
5881	Emydidae	*Pseudemys*	*gorzugi*		59	49	67	60	60
5882	Emydidae	*Pseudemys*	*gorzugi*		154	103	174	129	620
5883	Emydidae	*Pseudemys*	*gorzugi*		141	94	162	124	540
5884	Emydidae	*Pseudemys*	*gorzugi*		167	109	193	136	900
5896	Emydidae	*Trachemys*	*scripta*	*elegans*	203	133	210	165	1,361
5900	Emydidae	*Trachemys*	*scripta*	*elegans*	159	114	178	140	794
5902	Emydidae	*Trachemys*	*scripta*	*elegans*	210	140	216	165	1,361
5905	Emydidae	*Trachemys*	*scripta*	*elegans*	159	114	165	140	680
5908	Emydidae	*Trachemys*	*scripta*	*elegans*	114	89	127	102	227
5911	Emydidae	*Trachemys*	*scripta*	*elegans*	191	127	203	152	1,134

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5994	Emydidae	*Trachemys*	*scripta*	*elegans*	214	136			1,820
5909	Emydidae	*Trachemys*	*scripta*	*elegans*	127	95	165	114	227
5910	Emydidae	*Trachemys*	*scripta*	*elegans*	159	108	159	133	454
5912	Emydidae	*Trachemys*	*scripta*	*elegans*	171	114	191	140	907
7378	Emydidae	*Trachemys*	*scripta*	*elegans*	197	130			
7950	Bataguridae	*Siebenrockiella*	*crassicollis*						
7951	Bataguridae	*Siebenrockiella*	*crassicollis*						
7952	Bataguridae	*Heosemys*	*grandis*						
5472	Chelidae	*Chelodina*	*mccordi*						891
5473	Bataguridae	*Callagur*	*borneoensis*						2,041
5480	Bataguridae	*Geoemyda*	*nigrican*						537
5481	Chelidae	*Chelodina*	*mccordi*						891
5482	Chelidae	*Chelodina*	*siebenrocki*						357
5493	Bataguridae	*Heosemys*	*grandis*						352
5505	Bataguridae	*Siebenrockiella*	*crassicollis*		132	105			720
5506	Bataguridae	*Siebenrockiella*	*crassicollis*		136	110			720
5507	Pelomedusidae	*Pelusios*	*subniger*		155	105			800
5512	Bataguridae	*Cyclemys*	*dentata*		154	115			640
5514	Kinosternidae	*Kinosternon*	*sonoriense*		139	73			460
5515	Kinosternidae	*Staurotypus*	*triporcatus*						4,140
5516	Pelomedusidae	*Pelusios*	*subniger*		174	121			1,220
5517	Chelidae	*Phrynops*	*gibbus*		155	122			600
5519	Pelomedusidae	*Pelusios*	*subniger*		162	127			700

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5520	Chelidae	*Phrynops*	*gibbus*		179	128			1,100
5521	Kinosternidae	*Staurotypus*	*triporcatus*						
5522	Bataguridae	*Sacalia*	*bealeyi*		116	87			200
5524	Chelidae	*Phrynops*	*gibbus*		141	104			540
5526	Bataguridae	*Cyclemys*	*dentata*		129	97			400
5530	Chelidae	*Phrynops*	*platycephala*		120	83			220
5531	Chelidae	*Phrynops*	*platycephala*		134	85			280
5836	Chelidae	*Chelodina*	*siebenrocki*						1,460
5837	Chelidae	*Chelodina*	*siebenrocki*						1,940
5838	Chelidae	*Chelodina*	*siebenrocki*						1,040
5839	Chelidae	*Chelodina*	*siebenrocki*						3,380
5840	Chelidae	*Elseya*	*branderhorstii*						1,800
5841	Chelidae	*Elseya*	*branderhorstii*						1,180
5842	Chelidae	*Elseya*	*branderhorstii*						480
5843	Chelidae	*Elseya*	*branderhorstii*						2,000
5844	Chelidae	*Elseya*	*branderhorstii*						1,900
5845	Chelidae	*Elseya*	*branderhorstii*						
5846	Chelidae	*Elseya*	*branderhorstii*						1,020
5847	Chelidae	*Elseya*	*branderhorstii*						1,960
5848	Chelidae	*Elseya*	*branderhorstii*						760
5849	Chelidae	*Elseya*	*branderhorstii*						1,260
5850	Chelidae	*Elseya*	*branderhorstii*						1,500
5851	Kinosternidae	*Staurotypus*	*triporcatus*						800

APPENDIX H – TURTLE MEASUREMENT DATA

MF Sample Number	Family	Genus	Species	Subspecies	Plastron Length (mm)	Plastron Width (mm	Carapace Length (mm)	Carapace Width (mm)	Weight (g)
5853	Chelidae	*Phrynops*	*geoffroanus*						1,140
5854	Chelidae	*Phrynops*	*geoffroanus*						1,260
5855	Chelidae	*Phrynops*	*geoffroanus*						780
5471	Chelidae	*Emydura*	*subglobosa*						2,080

REFERENCES

Alhaboudi, A.R., Pollard, D.A., & Holman, P.J. (2017). Molecular and morpholoigical characterization of a haemogregarine in the alligator snapping turtle, *Macrochelys temminckii* (Testudines: Chelydridae). *Parasitology Research 116*, 207-215. doi:10.1007/s00436-016-5280-2

Barta, J.R. (1989). Phylogenetic analysis of the class Sporozoea (Phylum Apicomplexa Levine, 1970): Evidence for the independent evolution of heteroxenous life cycles. *Journal of Parasitology, 75*(2), 195-206. doi:10.2307/3282766

Beyer, T.V., Svezhova, N.V., Radchenko, A.I., & Sidorenko, N.V. (2002). Parasitophorous vacuole: Morphofunctional diversity in different coccidian genera (A short insight into the problem). *Cell Biology International, 26*(10), 861-871. doi:10.1006/cbir.2002.0943

Cook, C.A., Lawton, S.P., Davies, A.J., & Smit, N.J. (2014). Reassignment of the land tortoise haemogregarine *Haemogregarina fitzsimonsi* Dias 1953 (Adeleorina: Haemogregarinidae) to the genus *Hepatozoon* Miller 1908 (Adeleorina: Hepatozoidae) based on parasite morphology, life cycle and phylogenetic analysis of 18S rDNA sequence fragments. *Parasitology, 13*, 1-10. doi:10.1017/S003118201400081X

Davies, A. (1995). The biology of fish haemogregarines. *Advances in Parasitology, 36*, 117-203. doi:10.1016/S0065-308X(08)60491-1

Davies, A., & Johnston, M.R.L. (2000). The biology of some intraerythrocytic parasites of fishes, amphibia, and reptiles. *Advances in Parasitology, 45*, 1-107. doi:10.1016/S0065-308X(00)45003-7

Davies, A., Smit, N.J., Hayes, P.M., Seddon, A.M., & Wertheim, D. (2004). *Haemogregarina bigemina* (Protozoa: Apicomplexa: Adeleorina) - past, present, and future. *Folia Parasitological, 51*(2-3), 99-108. doi:10.14411/fp.2004.015

Desser, S.S., Hong, H., & Martin, D.S. (1995). The life history, ultrastructure, and experimental transmission of *Hepatozoon catesbianae* n. comb., an Apicomplexan parasite of the bullfrog, *Rana catesbeiana* and the mosquito, *Culex territans* in Algonquin Park, Ontario. *Journal of Parasitology 81*(2), 212-222. doi:10.2307/3283922

Divers, S.J., & Mader, D.R. (2005). *Reptile Medicine and Surgery* (Second ed. Vol. 801).

Dodd, C.K. (2016). *Reptile ecology and conservation : a handbook of techniques* (First ed.). Oxford: Oxford University Press.

Dresser, C.M., Ogle, R.M., & Fitzpatrick, B.M. (2017). Genome scale assessment of a species translocation program. *Conservation Genetics, 18*, 1191-1199. doi:10.1007/s10592-017-0970-6

Dvorakova, N., Kvicerova, J., Papousek, I., Javanbakht, H., Tiar, G., Kami, H., & Siroky, P. (2014). Haemogregarines from western Palaearctic freshwater turtles (Genera *Emys, Mauremys*) are conspecific with *Haemogregarina stepanowi* Danilewsky, 1885. *Parasitology, 141*(4), 522-530. doi:10.1017/S0031182013001820

Fahrig, L. (2003). Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution, and Systematics, 34*, 487-515. doi:10.1146/annurev.ecolsys.34.011802.132419

Gibbons, J.W., Scott, D.E., Ryan, T.J., Buhlmann, K.A., Tuberville, T.D., Metts, B.S., Greene, J.L., Mills, T., Leiden, Y., Poppy, S., & Winne, C.T. (2000). The global decline of reptiles, deja vu amphibians. *BioScience, 50*(8), 543-666. doi:10.1641/0006-3568(2000)050[0653:TGDORD]2.0.CO;2

Haklova-Kocikova, B., Hiznanova, A., Majlath, I., Racka, K., Harris, D.J., Foldvari, G., Tryjanowski, P., Kokosova, N., Malcekova, B., & Majlathova, V. (2014). Morphological and molecular characterization of *Karyolysus*--a neglected but common parasite infecting some European lizards. *Parasites & Vectors, 7*, 555. doi:10.1186/s13071-014-0555-x

Harris, J.B.C., Reid, J.L., Scheffers, B.R., Wanger, T.C., Sodhi, N.S., Fordham, D.A., & Brook, B.W. (2012). Conserving imperiled species: A comparison of the IUCN red list and U.S. endangered species act. *Conservation Letters, 5*, 64-72. doi:10.1111/j.1755-263X.2011.00205.x

Hartley, M., & Sainsbury, A. (2017). Methods of disease risk analysis in wildlife translocations for conservation purposes. *Ecohealth, 14*(Supplement 1), 16-29. doi:10.1007/s10393-016-1134-8

Ishtiaq, F., Rao, M., Huang, X., & Bensch, S. (2017). Estimating prevalence of avian haemosporidians in natural populations: A comparative study on screening protocols. *Parasites & Vectors, 10*(1), 127. doi:10.1186/s13071-017-2066-z

Jacobson, E.R. (1993). Implications of infectious diseases for captive propagation and introduction programs of threatened/endangered reptiles. *Journal of Zoo and Wildlife Medicine, 24*(3), 245-255.

Javanbakht, H., & Sharifi, M. (2014). Prevalence and intensity of *Haemogregarina stepanowi* (Apicomplexa: Haemogregarinidae) in two species of freshwater turtles (*Mauremys caspica* and *Emys orbicularis*) in Iran. *Journal of Entomology and Zoology Studies, 2*(4), 155-158. doi:10.1139/z92-018

Karadjian, G., Chavatte, J.M., & Landau, I. (2015). Systematic revision of the Adeleid haemogregarines, with creation of *Bartazoon* n. g., Reassignment of *Hepatozoon argantis* Garnham, 1954 to *Hemolivia*, and molecular data on *Hemolivia stellata*. *Parasite, 22*, 31. doi:10.1051/parasite/2015031

Keesing, F., Belden, L.K., Daszak, P., Dobson, A., Harvell, C.D., Holt, R.D., Hudson, P., Jolles, A., Jones, K.E., Mitchell, C.E., Myers, S.S., Bogich, T., & Ostfeld, R.S. (2010). Impacts of biodiversity on the emergence and transmission of infectious diseases. *Nature, 468*, 647-652. doi:10.1038/nature09575

Kim, B., Smith, T.G., & Desser, S.S. (1998). The life history and host specificity of *Hepatozoon clamate* (Apicomplexa: Adeleorina) and ITS-1 nucleotide sequence variation of *Hepatozoon* species of frogs and mosquitos from Ontario. *Journal of Parasitology 84*(4), 789-797.

Kirmse, P. (1979). Redescription of the life cycle of *Haemogregarina simondi* (Laveran and Mesnil, 1901) in its vertebrate host the marine fish *Solea solea* (Linnaeus). *Zeitschrift fuer Parasitenkunde, 59*(2), 141-150.

Kvicerova, J., Hypsa, V., Dvorakova, N., Mikulicek, P., Jandzik, D., Gardner, M.G., Javanbakht, H., Tiar, G., & Siroky, P. (2014). *Hemolivia* and *hepatozoon*: Haemogregarines with tangled evolutionary relationships. *Protist, 165*(5), 688-700. doi:10.1016/j.protis.2014.06.001

Lambert, M.R., Nielsen, S.N., Wright, A.N., Thomson, R.C., & Shaffer, H.B. (2013). Habitat features determine the basking distribution of introduced red-eared sliders and native western pond turtles. *Chelonian Conservation and Biology 12*(1), 192-199. doi:0.2744/CCB-1010.1

Lobban, G.L. (2003). *Molecular identification, phylogeny and systematics of Haemogregarina in turtles.* Masters thesis, Texas State University San Marcos, TX.

Maia, J.P., Carranza, S., & Harris, D.J. (2016). Comments on the systematic revision of adeleid haemogregarines: Are more data needed? *Journal of Parasitology, 102*(5), 549-552. doi:10.1645/15-930

Maia, J.P., Harris, D.J., Carranza, S., & Gomez-Diaz, E. (2014). A comparison of multiple methods for estimating parasitemia of hemogregarine hemoparasites (Apicomplexa: Adeleorina) and its application for studying infection in natural populations. *PLoS One, 9*(4), e95010. doi:10.1371/journal.pone.0095010

Maia, J.P., Harris, D.J., Carranza, S., & Gomez-Diaz, E. (2016). Assessing the diversity, host-specificity and infection patterns of Apicomplexan parasites in reptiles from Oman, Arabia. *Parasitology, 143*(13), 1730-1747. doi:10.1017/S0031182016001372

Mansfield, S., & Mills, N.J. (2004). A comparison of methodologies for the assessment of host preference of the gregarious egg parasitoid *Trichogramma platneri*. *Biological Control, 29*, 332-340 doi:10.1016/j.biocontrol.2003.09.004

Mathew, J.S., Van Den Bussche, R.A., Ewing, S.A., Malayer, J.R., Latha, B.R., & Panciera, R.J. (2000). Phylogenetic relationships of Hepatozoon (Apicomplexa: Adeleorina) based on molecular, morphologic, and life-cycle characters. *Journal of Parasitology, 86*(2), 366-372. doi:10.1645/0022-3395(2000)086[0366:PROHAA]2.0.CO;2

Mercier, C., Adjogble, K.D., Daubener, W., & Delauw, M.F. (2005). Dense granules: Are they key organelles to help understand the parasitophorous vacuole of all Apicomplexa parasites? *International Journal for Parasitology 35*(8), 829-849. doi:10.1016/j.ijpara.2005.03.011

Mikota, S.K., & Aguilar, R.E. (1996). Management protocols for animals in captive propagation and reintroduction programmes. *Scientific and Technical Review of the Office International des Epizooties (Paris), 15*(1), 191-208.

Moco, T.C., O'dwyer, L.H., Vilela, F.C., Barrella, T.H., & Silva, R.J. (2002). Morphologic and morphometric analysis of *Hepatozoon* spp. (Apicomplexa, Hepatozoidae) of snakes. *Memorias do Instituto Oswaldo Cruz, 97*(8), 1169-1176. doi:10.1590/S0074-02762002000800019

Morrissette, N.S., & Sibley, L.D. (2002). Cytoskeleton of Apicomplexan parasites. *Microbiology and Molecular Biology Reviews, 66*(1), 21-38. doi:10.1128/MMBR.66.1.21-38.2002

Ozvegy, J., Marinkovic, D., Vucicevic, M., Gajic, B., Stevanovic, J., Krnjaic, D., & Aleksic-Kovacevic, S. (2015). Cytological and molecular identification of *Haemogregarina stepanowi* in blood samples of the European pond turtle (*Emys orbicularis*) from quarantine at Belgrade Zoo. *Acta Veterinaria-Beograd, 65*(4), 443-453. doi:10.1515/acve-2015-0037

Paterson, W.B., & Desser, S.S. (1976). Observations on *Haemogregarina balli* sp. n. from the common snapping turtle, *Chelydra serpentina*. *Journal of Protozoology 23*(2), 294-301. doi:10.1111/j.1550-7408.1976.tb03775.x

Polo-Cavia, N., Lopez, P., & Martin, J. (2012). Feeding status and basking requirements of freshwater turtles in an invasion context. *Physiology & Behavior, 105*, 1208-1213. doi:10.1016/j.physbeh.2011.12.020

Rangel-Mendoza, J., Weber, M., Zenteno-Ruiz, C.E., Lopez-Luna, M.A., & Barba-Macias, E. (2009). Hematology and serum biochemistry comparison in wild and captive Central American river turtles (*Dermatemys mawii*) in Tabasco, Mexico. *Research in Veterinary Science, 87*, 313-318. doi:10.1016/j.rvsc.2009.03.006

Readel, A.M., Phillips, C.A., & Wetzel, M.J. (2008). Leech parasitism in a turtle assemlage: effects of host and environmental characteristics. *Copeia 2008*(1), 227-233. doi:10.1643/CH-06-212

Rossow, J.A., Hernandez, S.M., Sumner, S.M., Altman, B.R., Crider, C.G., Gammage, M.B., Segal, K.M., & Yabsley, M.J. (2013). *Haemogregarine* infections of three species of aquatic freshwater turtles from two sites in Costa Rica. *International Journal for Parasitology: Parasites and Wildlife, 2*, 131-135. doi:10.1016/j.ijppaw.2013.02.003

Siddall, M.E., & Desser, S.S. (1991). Merogonic development of *Haemogregarina balli* (Apicomplexa: Adeleina: Haemogregarinidae) in the leech *Placobdella ornata* (Glossiphoniidae), its transmission to a chelonian intermediate host and phylogenetic implications. *Journal of Parasitology 77*(3), 426-436. doi:10.2307/3283131

Siroky, P., Kamler, M., & Moody, D. (2004). Long-term occurrence of *Hemolivia* cf. *Mauritania* (Apcomlexa: Adelina: Haemogregarinidae) in captive tested marginal (Reptile: Testudinidae): Evidence for cyclic merogony? *Journal of Parasitology, 90*(6), 1391-1393. doi:10.1645/GE-3306

Sloboda, M., Kamler, M., Bulantova, J., Votypka, J., & Modry, D. (2007). A new species of *Hepatozoon* (Apicomplexa: Adeleorina) from *Python regius* (Serpentes: Pythonidae) and its experimental transmission by a mosquito vector. *Journal of Parasitology 93*(5), 1189-1198. doi:10.1645/GE-1200R.1

Smit, N.J., & Davies, A.J. (2001). An encapsulated haemogregarine from the evileye pufferfish in South Africa. *Journal of the Marine Biological Association of the United Kingdom, 81*, 751-754. doi:10.1017/S0025315401004556

Smith, T.G., Kim, B., & Desser, S.S. (1999). Phylogenetic relationships among *Hepatozoon* species from snakes, frogs and mosquitoes of Ontario, Canada, determined by ITS-1 nucleotide sequences and life-cycle, morphological and developmental characteristics. *International Journal for Parasitology, 29*(2), 293-304. doi:10.1016/S0020-7519(98)00198-2

Verneau, O., Palacios, C., Platt, T., Alday, M., Billard, E., Allienne, J.-F., Basso, C., & Du Preez, L.H. (2011). Invasive species threat: Parasite phylogenetics reveals patterns and processes of host-switching between non-native and native captive freshwater turtles. *Parasitology, 138*, 1778-1792. doi:10.1017/S0031182011000333

Vilcins, I.M.E., Old, J.M., & Deane, E. (2009). Detection of a *Hepatozoon* and spotted fever group *Rickettsia* species in the common marsupial tick (*Ixodes tasmani*) collected from wild Tasmanian devils (*Sarcophilus harrisii*), Tasmania. *Veterinary Parasitology, 162*(1-2), 23-31. doi:10.1016/j.vetpar.2009.02.015

Woo, P.T.K. (1969). The life cycle of *Trypanosoma chrysemydis*. *Canadian Journal of Zoology, 47*(6), 1139-1151. doi:10.1139/z69-178

Zimmerman, L.A., Vogel, L.A., & Bowden, R.M. (2010). Commentary: Understanding the vertebrate immune system: Insights from the reptilian perspective *Journal of Experimental Biology 213*, 661-671. doi:10.1242/jeb.038315