STOMACH CONTENT ANALYSIS OF THE INVASIVE SMALL INDIAN

MONGOOSE (*HERPESTES AUROPUNCTATUS*) FROM PUERTO RICO

by

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVIATIONS

Abbreviation

IUCN - International Union for Conservation of Nature

SIM - small Indian mongoose

USDA - United States Department of Agriculture

ABSTRACT

Since their introduction to Puerto Rico as a form of biological pest control in the late 1800's, the small Indian mongoose (*Herpestes auropunctatus*) has been identified as a reservoir for several zoonotic diseases and has been suggested as a factor affecting native Puerto Rican fauna. Mongoose are considered generalist predators that readily switch prey consumption depending on prey availability. There are seven ecological zones in Puerto Rico that vary in rainfall, elevation, and vegetations thus creating heterogeneous environments that likely differ in prey abundance, which presumably results in diverging prey use by mongooses in distinct ecological zones. Prior dietary analyses conducted on introduced mongooses in Puerto Rico have focused on individual ecological zones. For the present study, I contrasted mongoose diets from the subtropical moist forest zone and subtropical dry forest zones. Stomach contents were separated and analyzed to determine aggregate percent composition of prey remains for 5 categories (invertebrate, reptile, mammal, vegetation, and other). Of 51 mongoose stomachs analyzed (Dry, n=22, Moist, n=29), there were differences in category compositions across all mongooses but there were no differences in compositions of prey remains between ecological sites. Invertebrates comprised the largest category of prey (Dry=13.7%, Wet=9.4%) used by mongooses at both ecological zones. Despite their large ecological differences, proximity of these zones to each other likely allowed prey distributions to overlap across both zones. Future studies on prey abundance per ecological zone would provide insights into whether mongooses are selecting or using

prey based on their availability.

I. INTRODUCTION

An introduced invasive species is defined as a species which has successfully established in a non-native ecosystem and is characterized as a factor in disruption of that ecosystem such that the species is considered a threat to native biodiversity (IUCN 2000, Park 2004). Second to habitat loss, the effects from an invasive species have been characterized as one of the greatest threats to biodiversity worldwide (Vitousek et al. 1997). When introduced and established in a non-native habitat, invasive species might encounter advantageous conditions such as absence of natural predators and an abundance of resources, allowing amplified proliferation and success (Moors and Atkinson 1984, Courchamp et al. 2003). Once established, the effects from an invasive species can be through herbivory, competition, hybridization, disease transmission, or predation native species (Ebenhard 1988). In addition to direct impacts, invasive species may also fill a spatial niche, creating new interactions between native and non-native species that can alter an ecosystem (Braga et al. 2018). Further, impacts may be compounded by human-induced or environmental changes (Vitousek 1996). Invasive species impacts studies usually occur in evaluative fashion, however, after the invasion begins to negatively affect these ecosystems.

Invasions can affect any ecosystem, but island ecosystems are especially vulnerable to any negative effects from a non-native species (Courchamp et al. 2003). Isolation has allowed island biotas to evolve with little to no influence from outside factors thus creating unique ecosystems (Park 2004). Island ecosystems are of concern because they are considered exceptionally biodiverse “hotspots” or areas with a high concentration of specialized habitat and endemism (Myers 2000). If invasion of an island occurs, survival of native species could be threatened because they have no prior adaptations or defenses against potential impacts from a non-native species. This makes islands highly susceptible to harmful impacts from species introductions (Gorman 1975, Courchamp et al. 2003). Most island invasions are the result of accidental or intentional anthropogenic introductions of foreign species (Park 2004). A high percentage of historic introductions were deliberate with no prior understanding of how an introduction could alter the ecology of islands (Mack et al. 2000).

For example, in the 19th Century, the West Indies (The Lucayan Archipelago and the Greater and Lesser Antilles) were suffering agricultural damages from rodent populations that fed upon sugar cane crops. As an attempt to control rodents, small Indian mongoose (*Herpestes auropunctatus; hereafter* SIM or mongoose) individuals from the state of West Bengal, India, were released on Jamaica in 1872 as a form of biological pest control (Nellis 1989, Yamada and Sugimura 2004). Mongooses have a reputation as generalist predators that feed heavily on rodents and snakes and are assumed to control these prey populations in their native range of southeastern portions of the Middle East, India, South China, and the Malayan Peninsula (Nellis 1989, Siddiqui et al. 2003, Yamada and Sugimura 2004, Hays and Conant 2007). A generalist species is defined as one that exhibits prey-switching behavior as prey densities decrease toward a certain threshold, thus increasing the diversity of prey items on which they feed (Panzacchi et al. 2008). Because of this characteristic, a mongoose's dietary composition can vary based on densities of prey available at different geographical locations. In both their native and introduced geographical range, SIM consume prey items that are abundant within their distribution (Gorman 1975, Siddiqui et al. 2003, Barun et al. 2011, Kalle et al. 2012).

After the initial SIM introduction, there was an observed decrease in the rodent population which was correlated with a decrease in sugar cane damage (Pimentel 1955, Hays and Conant 2007). Between 1882 and 1884, other Caribbean islands also imported SIM from the introduced Jamaican population (Pimentel 1955). Small Indian mongoose have been introduced to 64 islands worldwide and, thus, have been described as one of the world's 100 most invasive species (IUCN 2000, Barun et al. 2011). Specifically, after being introduced to Puerto Rico, SIM were identified as a reservoir for several zoonotic diseases, including the rabies virus, and were suggested to prey on native herpetofauna and avifauna (Pimentel 1955, Nellis and Everard 1983, Viella and Zwank 1993).

Herpetofauna conservation is of particular concern because they are threatened by habitat loss (Greenhawk 2013). Much of Puerto Rico's native terrestrial vertebrate biomass is comprised of reptiles and anurans (Montes and Brokaw 2010); there are no extant species of native terrestrial mammals. Predation by SIM on native herpetofauna could have a negative impact on herpetofauna populations because they have not yet adapted defense mechanisms against SIM. Herpetofauna may be most at risk to SIM predation in in places of higher elevation. Though reptile and anuran species are common throughout the island, species richness tends to be higher in mountainous areas, mosaics of forest and grassland (Gould 2008).

Although there have been dietary studies conducted on the introduced SIM from Puerto Rico, there has not been a study that contrasts prey use among the island's six ecological zones: Subtropical Dry Forest, Subtropical Moist Forest, Subtropical Wet

Forest, Subtropical Rain Forest, Lower Montane Wet Forest, and Lower Montane Rain Forest (Ewel and Whitmore 1973; Figure 1). This is crucial because even though the SIM has successfully been established in Puerto Rico and have been observed throughout the entire island (excluding heavily urbanized and forested areas) (Pimentel 1955), environmental differences between zones may yield differences in what mongooses are consuming on Puerto Rico and may yield implications for herpetofauna. This study specifically examined the relationship between the time of mongoose capture and the total amount of content that is present within stomachs.

Hypothesis tested: Although SIM home ranges vary depending on location, mongooses introduced to Puerto Rico have an estimated average home range of only 2.2 ha (Nellis and Everard 1983, Hays and Conant 2007). This suggests that they cover only a small portion of Puerto Rico's six Ecological Zones at a time. The Luquillo Experimental Rainforest and surrounding areas (Subtropical Moist Forest, Subtropical Wet Forest, Subtropical Rain Forest, Lower Montane Wet Forest, and Lower Montane Rain Forest), in particular, are likely to have a greater diversity of reptile and anuran species than that of the forests in the Subtropical Dry Forest Zone (Ewel and Whitmore 1973). Because of their ubiquity and generalist foraging behavior, there may be a higher risk of SIM predation on reptiles and anurans in the Subtropical Moist Forest Zones than in Subtropical Dry Forest Zones.

H1: Mongooses captured in the Subtropical Moist Ecological Zone will have a greater representation of reptile and anuran vertebrate remains when compared to stomach content of mongooses captured in a Subtropical Dry Ecological Zone because the former has the greater diversity of reptile and anuran prey.

Small Indian mongoose prefer areas with tall grass where individuals forage entirely on the ground (Pimentel 1955), where insects are in abundance. Previous dietary analyses in Puerto Rico has revealed mongoose diet to be mostly composed of invertebrates followed by reptile prey items (Wolcott 1953, Pimentel 1955, Viella and Zwank 1993, Viella 1998).

H2: Similar to other SIM dietary studies in Puerto Rico, invertebrates will form the dominant component of stomach content regardless of ecological zone (Pimentel 1955, Nellis and Everard 1983, Viella and Zwank 1993).

The SIM is mostly a diurnal species, with much of their activity, including foraging, taking place during the day (Pimentel 1955, Nellis and Everard 1983). Because SIMs are diurnal, the time of capture may influence whether those mongooses will have had time to forage prior to capture. Presumably, mongooses captured in early morning may not have had an opportunity to feed before being captured, which would in turn yield an empty stomach when analyzed. This potential can have practical implications for researchers trying to ascertain prey use in this species.

H3: Stomach content of mongooses from both ecological zones that were captured during morning, or first trap check of the day will yield less total stomach content when compared to mongooses that were captured in afternoon or evening trap checks.

II. METHODS

Study Area: Each ecological zone differs in annual precipitation, altitude, topography, soil, and vegetation. This environmental variation presumably creates heterogenous densities of native fauna that have specialized habitat selections (Joglar et al. 2007). I focused on the Subtropical Dry Forest Zone and the Subtropical Moist Forest Zone for this study because of their stark environmental contrasts.

Subtropical Dry Forest Zone experiences extensive sunlight and is the driest of all six zones receiving only 600-1100 mm of rainfall annually. Most of the trees in this zone are deciduous and do not exceed 15 m in height. Forest types of this zone have few layers and most of the vegetation has low moisture content (Ewel and Whitmore 1973). The Subtropical Moist Forest Zone is the largest of the ecological zones and receives between 1000-2200 mm of rainfall annually. This zone contains moist limestone hills that are dominated by grasslands and is more diverse in vegetation types compared to that of the dry forest zone (Ewel and Whitmore 1973). Mongooses will likely encounter invertebrate prey items at the same rate in both zones, but vertebrate prey items, such as *Anolis sp*., *Amphesbeana sp*. and *Eleutherodacylus sp.* will likely differ in their abundance.

Sample collection occurred from May 2015 until August 2015. This study was conducted in collaboration with a funded U.S. Department of Agriculture (USDA) project that focused on the role of SIM as a potential host in maintaining cattle fever ticks (*Rhipicephalus microplus*) in the environment, thus, maintaining disease in Puerto Rican cattle populations. Therefore, sampling for the study was restricted to anthropogenically dominated environments. We trapped mongooses on five cattle farms (three in

Subtropical Moist Ecological Zone and two in the Subtropical Dry Ecological Zone) representing the vegetation types that are common for these zones (Figure 1).

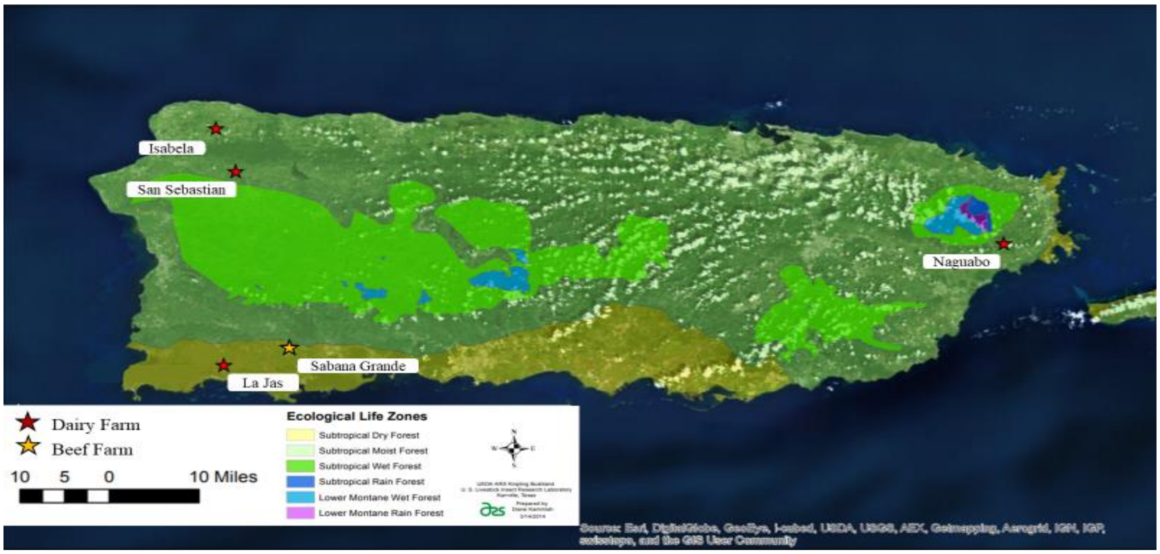


Figure 1: Ecological zones in relation to five farm sites where study was conducted in Puerto Rico. Subtropical Moist Forest farm sites: Isabela, Naguabo, and San Sebastian. Subtropical Dry Forest farm sites: Lajas and Sabana Grande.

Trapping: Research team members set fifty collapsible, galvanized small mammal Tomahawk Live Traps (61x15x15 cm, Model #203; 50x18x18 cm, Model #204; Tomahawk Live Trap Co., Hazelhurst, WI) along 20-40 trap transects. The team set trap lines in selected SIM tall grass habitat 15-20 m apart (Pimentel 1955). Transects included fence lines, around bodies of water, or game trails, places where mongoose frequent. The team conducted standard mammal trapping according to guidelines established by the American Society of Mammalogists. We baited traps baited with canned tuna fish in oil and checked/rebaited 3 times per day: dawn, noon, and late-afternoon (Pimentel 1955). Each study site was trapped for two weeks. To ensure captures and depending on trap success, the team changed transects 1-2 times during the trapping period. We closed traps during inclement weather to ensure that animals were not left in unsuitable conditions without the ability to take cover. When we captured an individual, we placed the Tomahawk trap containing animal into a canvas bag to be transported back to field laboratory to reduce stress.

Sample Collection: Research team members covered Tomahawk live traps containing an animal with a cloth bag around the trap opening. The trap door could then be opened, and mongoose was free to run into the bag. Once mongoose was inside the bag, we sealed it, and trap was removed. We placed the bag containing the mongoose into a larger plastic bag and then added a small vial containing cotton balls soaked in isoflurane into the bag for 20 to 40 minutes, depending on the size of the animal. We euthanized all trapped individuals by administering Isoflurane until the animal was unconscious and, then research personnel performed cervical dislocation. All procedures followed an approved animal use protocol at Texas State University (IACUC protocol #0514_0303_07) and followed guidelines established by the American Society of Mammalogists (Sikes et al. 2018).

We recorded total body length, tail length, left foot and ear length, mass, sex, ectoparasite load, and health conditions (Appendix A). We collected entire gastrointestinal tracts (esophagus, stomach, small intestine, and large intestine) for all individuals in a field lab setting and suspended in 95% ethanol. After all field activities were concluded for the season, we moved samples to Texas State University for further processing.

Gastrointestinal Analysis: Digestive tract processing took place in a field lab setting and immediately following capture. We removed stomachs and immediately fixed in 95% ethanol for travel. Because content was heavily manipulated after an endoparasite part of the USDA study, samples were returned to 70% ethanol where they remained until dietary analysis began. This procedure caused many of the samples to be heavily mixed and agitated with rendering much of the sample unidentifiable. I processed and analyzed contents of each stomach separately for dietary content in the laboratory at Texas State University.

I placed the stomach contents on a filter to remove as much ethanol as possible while not completely drying out samples to avoid sample destruction. I then placed the contents into a known volume and weight of 70% ethanol to determine the mass of only the stomach contents using a Mettler Toledo PB153 Analytical Balance (Mettler Toledo LLC, Columbus, OH). Following determination of mass, I separated and sorted the material using a Meiji Techno EMZ-10 Series 7X-45X Zoom Stereo Microscope (Meiji Techno America, San Jose, CA). I sorted the contents into five categories, invertebrates, mammals, reptiles, vegetation, and other. The category "other" was composed of either highly digested material that could not be identified, and is considered non-prey remains (garbage, plastic, sand, etc.), and canned tuna that was used to bait traps.

All remains were identified by morphological characteristics based on descriptions from Rivera (1978) and museum specimens from Texas State University (Appendix B). once separated, I measured the mass of each category using the same method as used for the total stomach content. Separated prey remains were then identified to lowest taxonomic level possible. Mammalian and reptilian remains were classified to genus level. Invertebrates were divided and classified to the lowest possible taxonomic category, by class, e.g. Arachnida (ticks, mites, spiders, scorpions), Diplopoda (millipedes) order, e.g. Hymenoptera (ants) and Blattodea (cockroaches and termites) or genus, e.g. Scolopendra (centipedes) (See Appendix).

Statistical Analysis: Aggregate percent of each category was determined based on methods from Martin et al. (1946) and Maehr and Brady (1986) using the following equation:

$$Aggregate\ Percent = \frac{\sum_{i}^{N} \frac{Vi}{Ti}}{N} \times 100$$

Where V*i* = volume of category *j* in stomach *i*, *Ti* = total volume from stomach *i*, and *N* = total number of stomachs sampled, separately for Subtropical Moist Forest and Subtropical Dry Forest. Results of aggregate percentages, ecological zone, and category of prey remains were compared using analysis of variance (One-way Analysis of Variance [ANOVA]) to determine if prey remains in stomach contents were different between the two ecological zones. I also conducted one-way ANOVA to determine differences between aggregate percentages from previous studies (determined in literature) and my study. I examined the relationship between time of capture for 39 mongooses and the total amount (g) of stomach content present in mongoose stomachs with ordinary least squares regression.

III. RESULTS

There were a total of 2,320 trap days May 2015-August 2015 with 61mongoose captures across all sites. Mean body measurements for males across all zones were total body length 596.3 mm (50.4 mm), tail length 257.4 mm (27.4 mm), hind foot 62.1 mm (4.4 mm), ear 19.9 mm (9.8 mm), and weight 718.9 g (178.2 g) (Table 1). Mean body measurements for females across all sites were total body length 551.3 mm (21.6 mm), tail length 245.8 (10.4 mm), hind foot 56.7 mm (4.3 mm), ear 17.3 mm (3.6 mm), and weight 505.8 g (89.6 g) (Table 1). Of the 61 samples collected, 10 were destroyed when preserved for travel. Of 51 viable mongoose stomachs analyzed (Dry, n=22, Moist, n=29) there was a difference in category compositions across all mongooses but there was no difference in compositions of prey remains between ecological sites ($P = 0.935$, $df = 1$).

Though stomach content did not differ between ecological zones, there was a difference in aggregate percentages of categories across all mongoose stomach contents from both ecological zones ($P < 0.001$, $df = 4$ Table1). The largest category of remains present was “other”. Invertebrates made up the largest category of identifiable prey remains. The most common identified remain from this category across all mongoose were centipedes (*Scolopendra sp.*). The second largest prey category was reptiles, with anoles (*Anolis sp.*) being the most common identifiable remain. Although my study and previous dietary analysis studies resulted in invertebrates yielding the highest composition followed by reptiles, there was a significant difference between results of previous studies and my current study ($P = < 0.001$, $df = 4$ Table 3). The third largest category was vegetation which consisted of grass remains and masticated seeds. The smallest category of remains was mammal (Table 2). Identified invertebrate remains narrowed to the level of order included: Achari, Araneae, Blattodea, Coleoptera, Diptera, Hymenoptera, Orthoptera, Siphonaptera. Remains identified to class included Diplopoda. Remains identified to genus included: whiptails (*Ameiva sp*.), blind snakes (*Amphisbaena sp.)*, mice (*Mus sp*.), rats (*Rattus sp*.), and centipedes (*Scolopendra sp*.) (See Appendix A). Anuran remains were not recovered.

I recorded time of capture for 39 of the 51 individuals that were processed for dietary analysis. Afternoon trap checks at 1200 yielded the most captures (n = 24), followed by evening checks at 1600 (n = 10), then morning traps checks at 0800 with the fewest captures (n = 4) When total stomach content was compared to time of mongoose capture, there was no difference. (*P* = 0.74, R-squared = 0.00301) (Figure 2).

Table 1: Morphometry averages by sex for Subtropical dry and moist ecological zones (mm and g).

Ecological zone	Sex	Total Body	Tail	Foot	Ear	Weight
Subtropical Dry	F	560	246	57	18	493
	M	594	248	61	21	718
Subtropical Moist	F	546	247	56	17	509
	M	599	266	63	19	720

Table 2: Aggregate Percentages of stomach content categories from subtropical dry and moist forest zones. Total prey consists of the total of all remains that are not from the category other.

Ecological Zone	*N*	Total Prey	Mammal	Reptile	Invertebrate	Vegetation	Other
Subtropical Dry	22	27.3%	1.8%	7.8%	13.7%	4.0%	73.3%
Subtropical Moist	29	20.2%	0.7%	8.3%	9.4%	1.8%	81.4%

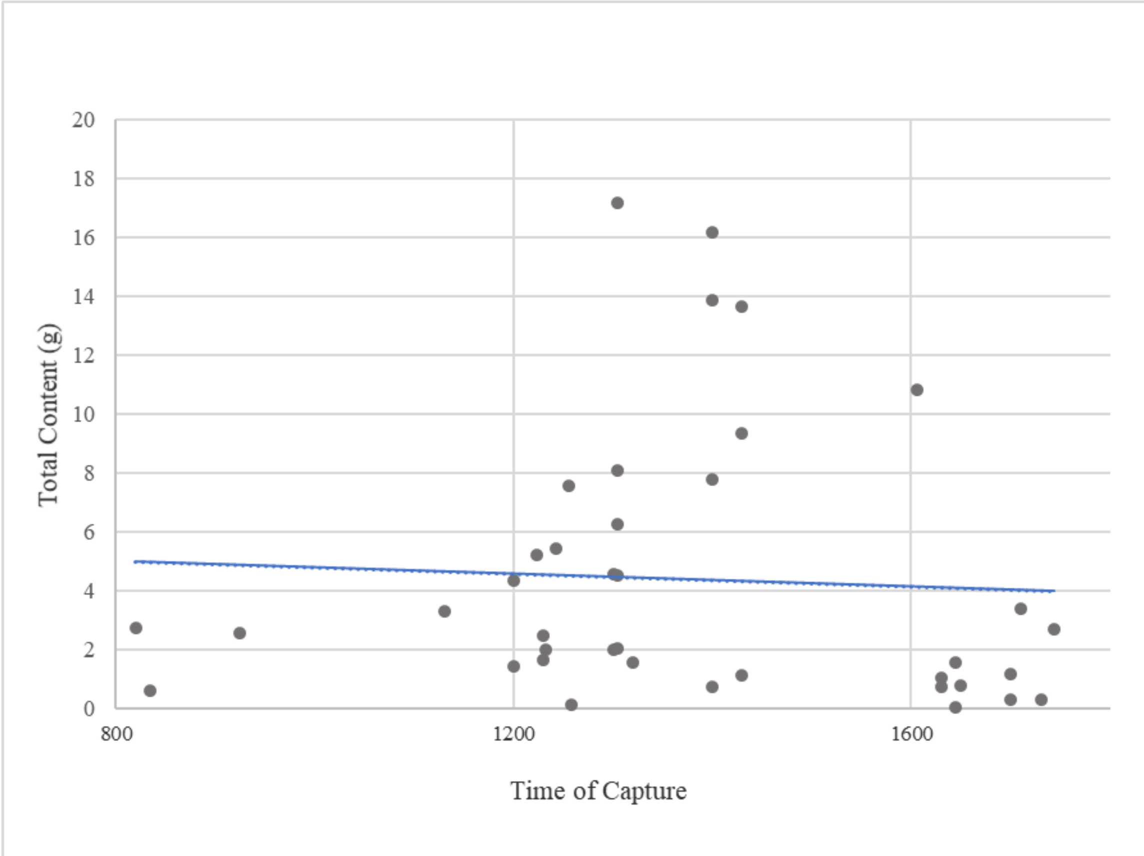


Figure 2: Ordinary least squares regression of relationship between total stomach content (g) and time of mongoose capture. 3 trap checks were at 0800, 1200, 1600. (*R-squared = 0.003*; *P = 0.74*)

VI. DISCUSSION

Small Indian mongooses continue to select prey in Puerto Rico in ways that are consistent with historical behavior. Much of what they encounter are invertebrate species that are present in forested and non-forested areas. Insect abundance has been observed to change from different seasonal factors (Pinheiro et al. 2002, Beltrán and Wunderle 2014). Some factors include food availability, climate, and rainfall. Insect populations increase with an increase in rainfall and moisture (Pinheiro et al. 2002). Much of Puerto Rico receives heavy rainfall throughout the year and invertebrates' populations are likely ubiquitous due to this abundant rainfall. Centipedes remains were most common within the invertebrate category. Though centipedes are most active at night, they can be found within leaf litter and superficial to the surface during the day when mongoose are foraging (Guizze et al. 2016). Aside from having access to an abundance of invertebrates, mongooses are also known to be instinctively insectivorous in their native distribution while foraging in similar open habitats (Mahmood et al. 2011).

Mongoose dietary behavior and selected habitat may reduce the chance of encounter with most reptile and anuran species compared to invertebrates. Small Indian mongoose are a diurnal species and select areas of open grassland and tend to avoid forested or urban areas (Pimentel 1955). Much of Puerto Rico's native terrestrial fauna that have faced population declines, such as rain tree frogs (*Eleutherodactylus sp.)* and blind snakes (*Amphesbeana sp.*), aggregate in heavily forested areas and are most active at night. Blind snakes are mostly fossorial, remaining burrowed within the ground during the day (Gehlbach et al. 1968). The rain tree frogs utilize diurnal retreat sites that may be more difficult for mongoose to find (Woolbright and Steweart 1987). Though declines in anole populations are likely not due to mongoose predation, population monitoring should continue to ensure that there are no changes in mongoose dietary compositions and associated declines of native anoles species because human and environmental landscape alterations may change SIM foraging patterns and prey availability (cite).

Comparing time of capture and total stomach content can be utilized for future studies to determine the time of day that a capture will yield the fullest stomach. This approach will reduce captures that result in empty stomachs. If a high number of mongooses are captured with empty stomachs they must either be excluded from study or this data may inflate results. Even though I did not detect a correlation between time of capture and total amount of stomach content in this study, results revealed a unimodal pattern with a peak in the middle of daylight hours (Figure 2). This suggests an optimal time for trapping to ensure high trap success and future SIM dietary studies will benefit by confirming this pattern with a larger sample size.

The best methods for management of an invasive species are prevention and eradication prior to the population becoming established (Prior et al. 2018). SIM are established on the island of Puerto Rico and, because management on the scale of an entire island would be difficult if not impossible, it is important that management strategies focus on areas where SIM are most active and may have the greatest impact on native species. This study demonstrated a homogeneous use of these diet categories among SIM individuals inhabiting these ecological zones suggesting that prey availability is likely similar between the two studied zones. It also suggests mongoose will consume the same prey regardless of whichever zone they are captured in. Though a difference in diet exist between these two different ecological zones did not exist in this study, knowledge of potential SIM impact on the rest of the ecological zones is needed. Our approach engages a process of elimination. Future research should determine compositions of mongoose stomach content across various zones to identify what SIM are eating and correlate those finding with declines in native species.

This study suggests that though various studies have been conducted on the impact of introduced SIM in Puerto Rico, it is unlikely that they are a leading factor in declines of these native species at this time (Wolcott 1953, Pimentel 1955, Viella and Zwank 1993, Viella 1998). There are certainly impacts from SIM on the anole population in (insert zones), but it is unlikely that they are responsible for a sharp decline. Research suggests that habitat destruction has a larger impact (Brash 1987, Vitousek et al. 1997, Greenhawk 2013). There is potential that as land use patterns shift on the island, that SIM impacts will also change, and they may have a synergistic effect on certain pretty species (cite).

Table 3: Results from my study and previous SIM dietary analysis on Puerto Rico.

	Pimentel (1955)	Viella and Zwank (1993)	Viella (1998)	Current Study (2015)
Study Site	Roosevelt Roads Naval Station	Guánica Forest	Luquillo Experimental Forest	Dry and Moist Zone
N	*56*	*34*	*18*	*51*
Total Prey	89%	85%	71%	47%
Vertebrate	9%	15%	33%	19%
Invertebrate	70%	70%	67%	23%
Vegetation	11%	15%	29%	6%

Limitations: A few factors should be considered to avoid limitations I encountered during this study. First, stomach content compositions are usually measured by drying content then identifying and separating prey remains (Vilella and Zwank 1993). Since samples were stored in ethanol, they required to be rehydrated prior to drying or the sample would be destroyed. To avoid sample loss, all contents remained in 70% ethanol during analysis. As a result, I needed to modify methods employed by Martin et al. (1946) and Maehr and Brady (1986) that analyzed stomach content within a solution using volumetric displacement. This allowed me to achieve similar results while not drying and weighing samples. I used volumetric displacement and weighing samples in ethanol to derive aggregate percentages of content. Use of other preserving and processing techniques likely would not be a factor to alter the quantifications of the identified material but, there would potentially be less unidentifiable material, reducing the inflated aggregate percentage of the "other" category. Genetic analysis may yield presence of some anuran species that could not be identified with the methods I used. Second, I only compared only two ecological zones out of six. Research should consider ecological zone as a potential parameter to ensure necessity for management is not overlooked because research was only conducted for one of the seven ecological zones. Third, other factors that could be considered in future dietary studies could be efforts to trap an even ratio of male and female. Males are usually more active, foraging throughout the day whereas females tend to remain behind in the den, especially during reproductive periods (Viella 1998). This potentially creates a sampling bias toward males that would require efforts to trap equal numbers of males and females to analyze another parameter. Fourth, seasonality may also affect dietary compositions. Males have been observed with a lower body weight despite there being an increase in abundance of prey in times (Coblentz and Coblentz 1985). Females reach their peak body weight during the month of February (Coblentz and Coblentz 1985). Though climate doesn't change much during the winter months, other factors may change due to seasonality.

This may yield differences in prey compositions.

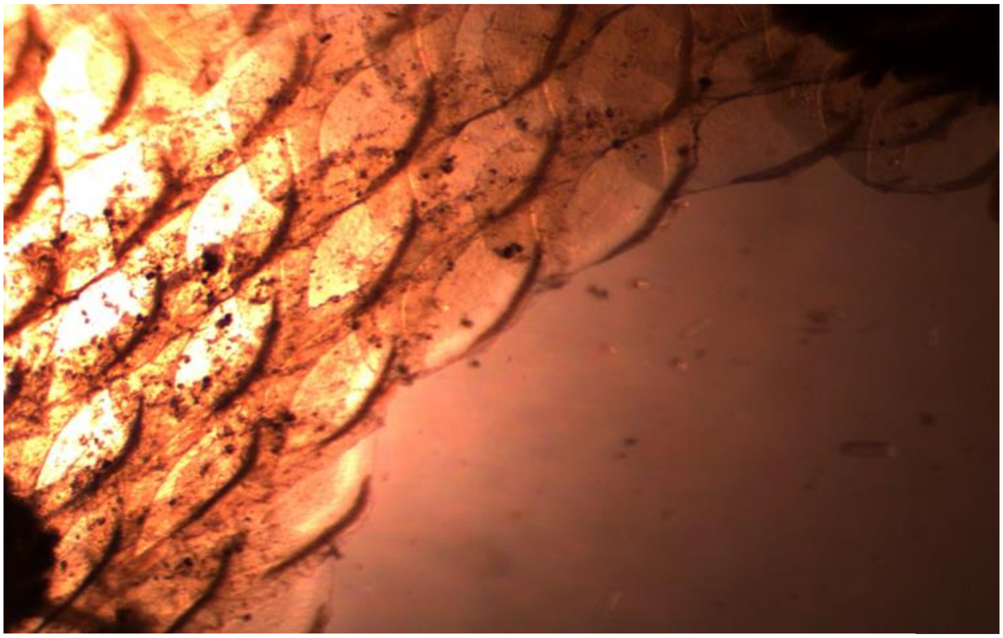
APPENDIX SECTION

Subtropical dry ecological zone: Prey remains presence/absence matrix for mongoose individuals captured in the subtropical dry ecological zone. Remains were identified and classified down to the lowest taxonomic level possible.

Classification	Genus						Order								Class	Vegetation
	Ameiva sp.	*Amphesbeana sp.*	*Anolis sp.*	*Mus sp.*	*Rattus sp.*	*Scholopendra sp.*	Achari	Araneae	Blattodea	Coleoptera	Diptera	Hymenoptera	Orthoptera	Siphonaptera	Diplopoda	
Site: Lajas																
MBT 29	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1
MBT 30	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1
MBT 32	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1
MBT 33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MBT 35	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1
MBT 36	0	0	1	0	1	1	0	0	1	0	1	1	0	0	0	1
MBT 37	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1
MBT 38	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1
MBT 39	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	1
MBT 42	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1
MBT 43	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
MBT 44	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
MBT 45	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
MBT 46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBT 47	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1
MBT 48	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0
MBT 56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBT 57	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	1
MBT 58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MBT 84	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1
Site: Sabana Grande																
MBT 49	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
MBT 50	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1
MBT 51	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1
MBT 52	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
MBT 53	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
MBT 54	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
MBT 55	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	1

Subtropical dry ecological zone: Prey remains presence/absence matrix for mongoose individuals captured in the subtropical dry ecological zone. Remains were identified and classified down to the lowest taxonomic level possible.

Classification	Genus						Order								Class	Vegetation
	Ameiva sp.	*Amphesbeana sp.*	*Anolis sp.*	*Mus sp.*	*Rattus sp.*	*Scholopendra sp.*	Achari	Araneae	Blattodea	Coleoptera	Diptera	Hymenoptera	Orthoptera	Siphonaptera	Diplopoda	
Site: Lajas																
MBT 29	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1
MBT 30	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1
MBT 32	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1
MBT 33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MBT 35	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1
MBT 36	0	0	1	0	1	1	0	0	1	0	1	1	0	0	0	1
MBT 37	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1
MBT 38	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1
MBT 39	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	1
MBT 42	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1
MBT 43	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
MBT 44	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
MBT 45	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
MBT 46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBT 47	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1
MBT 48	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0
MBT 56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBT 57	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	1
MBT 58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MBT 84	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1
Site: Sabana Grande																
MBT 49	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
MBT 50	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1
MBT 51	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1
MBT 52	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
MBT 53	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
MBT 54	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
MBT 55	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	1



Single layer of scales from genus *Amphesbeana*.

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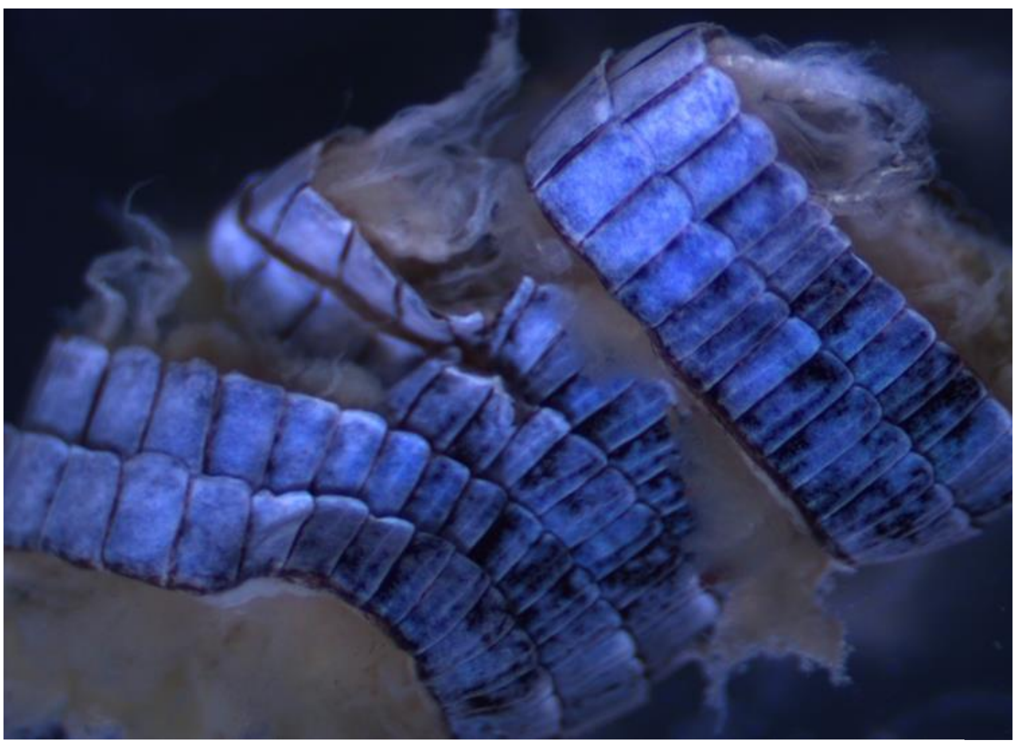
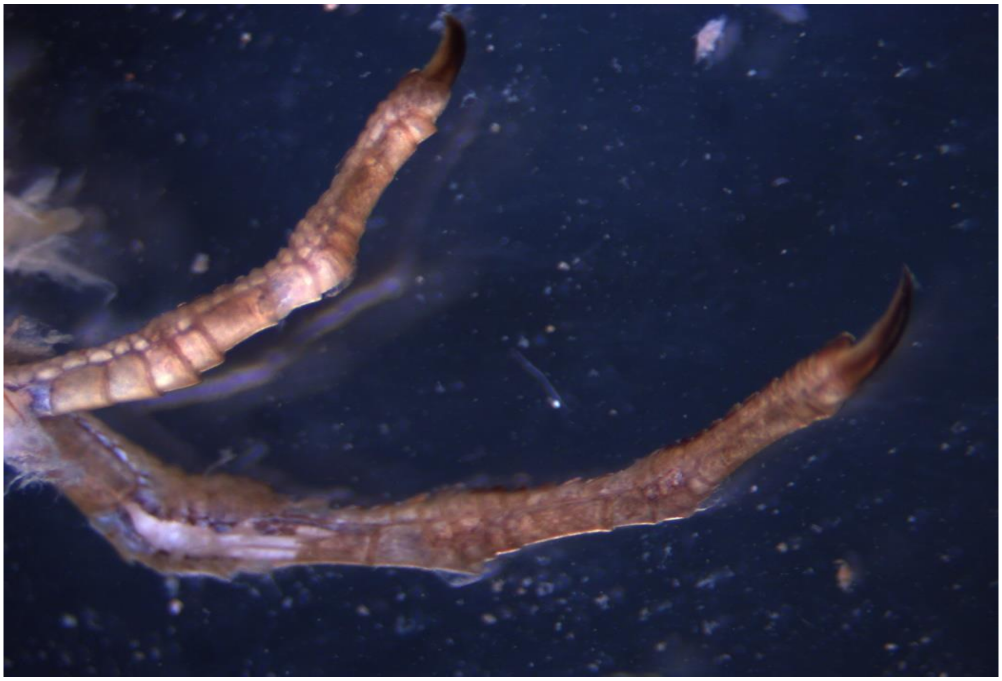
Scales and tissue of genus *Amphesbeana* (Single layer pictured above).

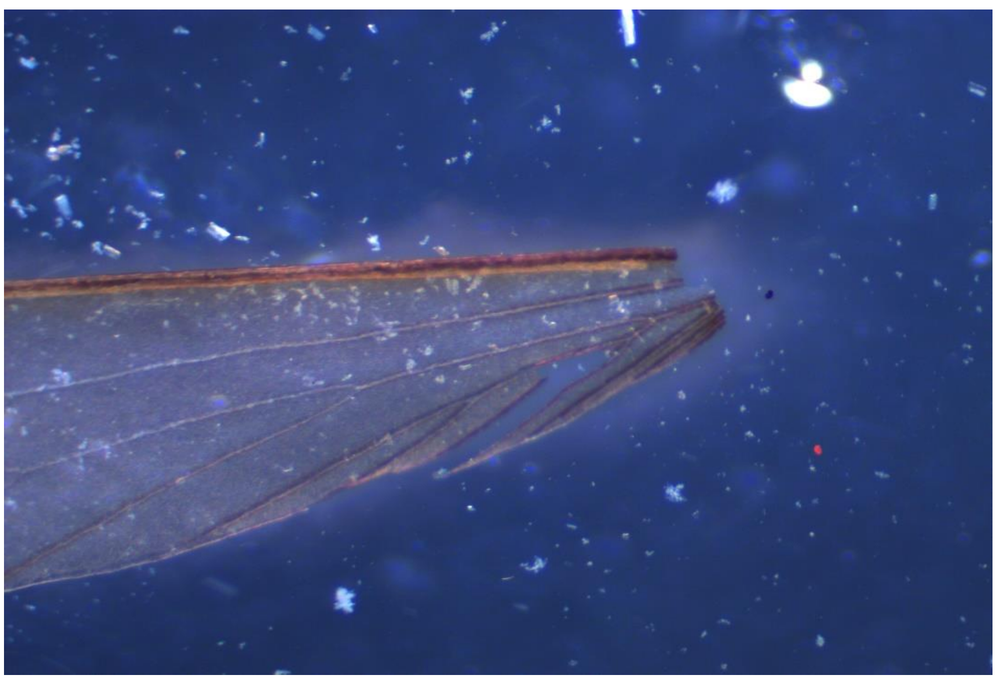
: Dentition from the genus *Anolis.*



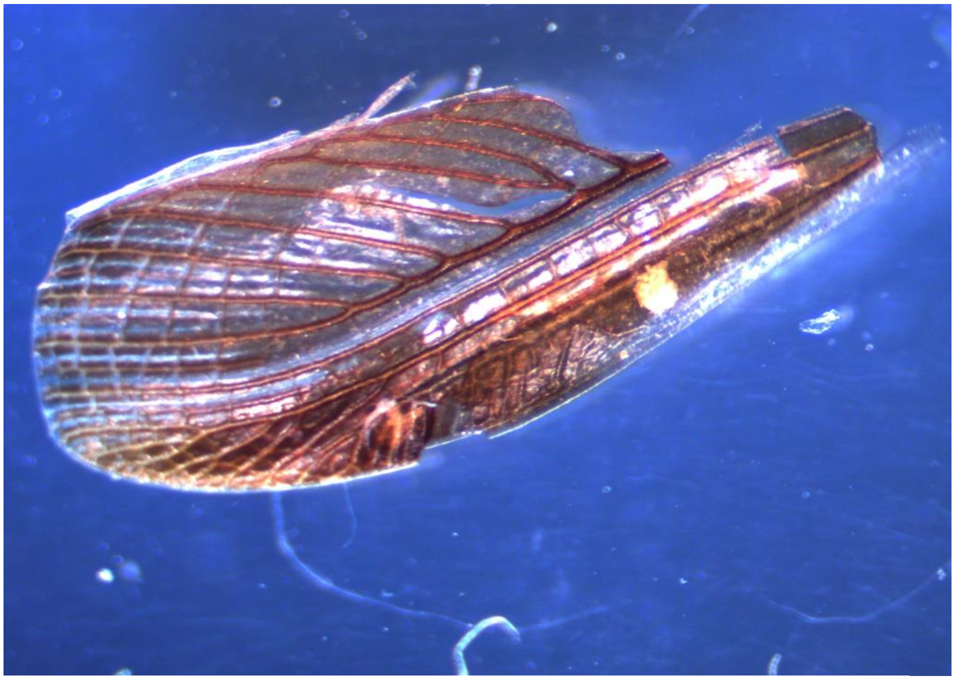
Scales and tissue of an individual from the genus *Ameiva*.



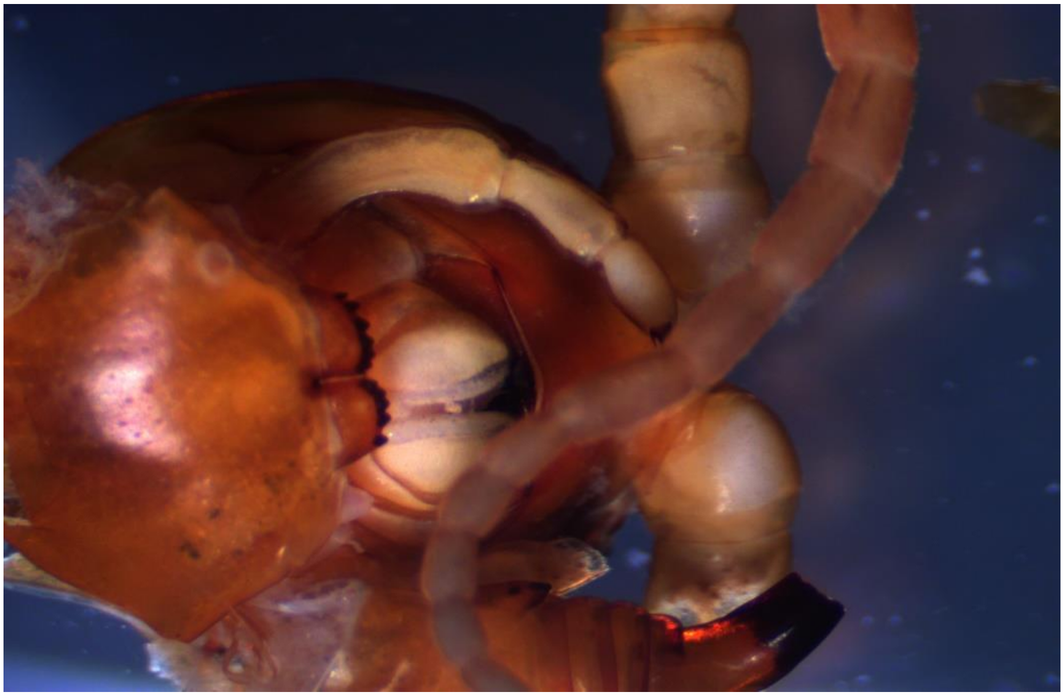
Hindfoot with claws from the genus *Ameiva*.



Wing from order Blattodea (termite). Thick fore wing vein is indicative of termites.


Wing from the order Blattodea (roach).


Remains from the order Hymenoptera (ants). Pictured: Abdomen, thorax, head, antennae, legs, and mouth parts for multiple individuals.

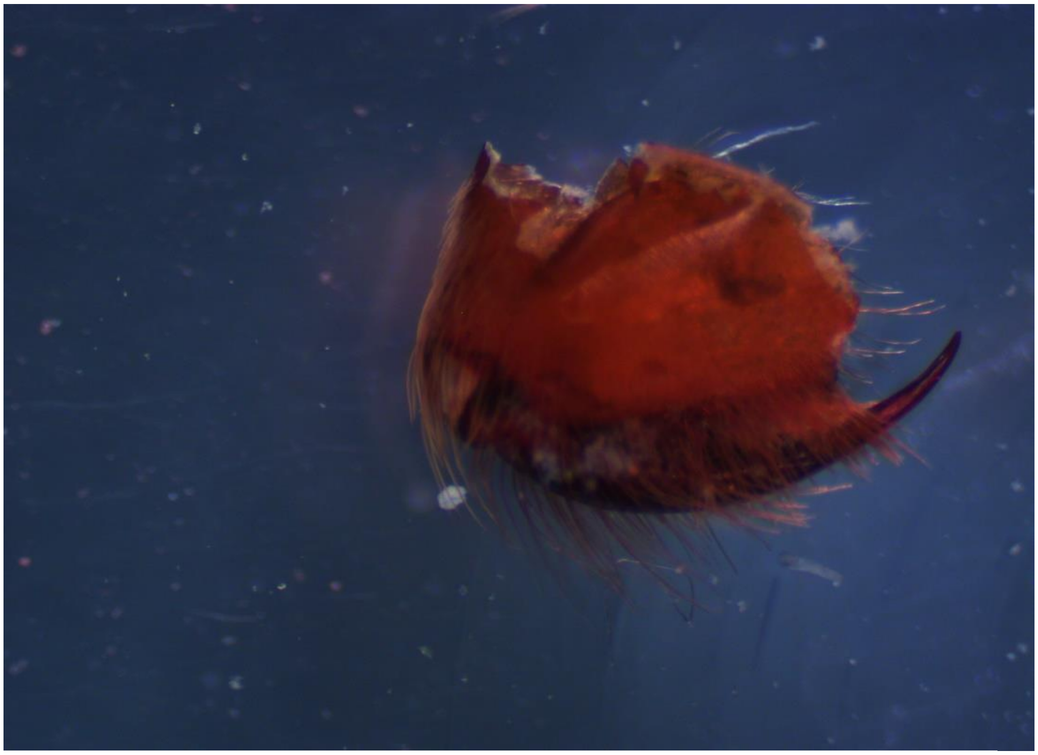


Ventral side of head from genus *Scholopendra* (centipede). Pictured: Antennae, mouth, forcipules (modified first legs), and head capsule.

Remains from the class Diplopoda (millipedes). Pictured. Anterior portion of millipede with attached antennae.

Remains from the order Araneae (spider). Pictured: Cephalothorax and abdomen segments.

Remains from the order Achari (tick)**.**

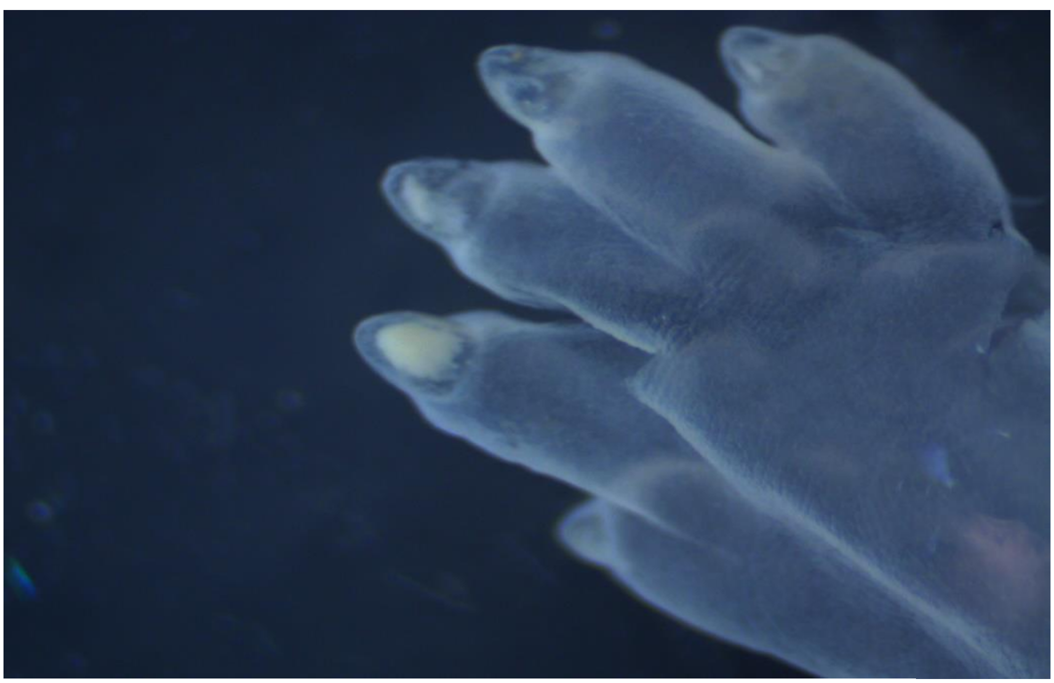

Remains from the order Araneae (spider). Pictured: Portion of chelicerae and attached fang.


Legs from the order Orthoptera (cricket). Pictured: Pretarsus, tarsus and tibia.

Caudal view of remains from the order Orthoptera (grasshopper). Pictured: Head, compound eye, and antennae.

Lateral view of grasshopper. Pictured: Mandible, labrum, mouth, and antennae.


Remain from the order Diptera (fly larvae).


Remains of rodent. Pictured: Epithelial tissue and attached claws.


Remains of rodent foot. Pictured: Digit with attached nail. Hair is still in tact and bone is visible.


Remains from the genus Rattus. Pictured: Portion from tail. Scaled texture of skin is indicative of *Rattus spp*.

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