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Species specificity between ectoparasites and rats in Monteverde, Costa Rica

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ABSTRACT

To determine if there is species specificity between ectoparasites and their host rats, I set up Sherman traps in various locations in Monteverde to capture rats. Once I obtained the rats I removed any ectoparasites present and observed them under a dissecting microscope for morphological characteristics. Species specificity is defined for this study as the prevalence of a certain type of ectoparasite to a specific species of rat. From my results, I determined that there is species specificity between ectoparasites and their host rats. Lice were species specific to the Cloud-dwelling Spiny Pocket Mouse, fleas to the Mexican Deer Mouse, ticks to the Fulvous Pygmy Rice Rats and Mexican Deer Mouse. Yellow mites were species specific to the Mexican Deer Mouse, Watson's Climbing Rat, and Cloud-dwelling Spiny Pocket Mouse. Red mites were specific to the Fulvous Pygmy Rice Rat. Brown mites and octopus mites were specific to the Alston's Singing Rat. The Hispid Cotton Rat that was caught contained no ectoparasites. The presence of pseudoscorpions in the Spiny Pocket Mouse further introduced a new variable that can potentially explain this species specificity, at least partially, for its predation on some ectoparasites. Hair morphologies of the rats were further examined in an attempt to explain the mechanism behind the species specificity.

Especificidad entre ectoparásitos y ratones en Monteverde, Costa Rica

RESUMEN

Para evaluar la especificidad entre ectoparásitos y ratones, dispuse trampas Sherman en varios sitios de Monteverde, para capturar ratones y registrar sus ectoparásitos. Observé las características morfológicas de los ectoparásitos bajo el estereoscopio y los identifiqué en morfo tipos. Definí "especificidad" como la prevalencia de cierto tipo de ectoparásito en alguna especie de ratón. De mis resultados, determiné que sí hay especificidad entre ectoparásitos y grupos de ratones hospederos. Encontré piojos en ratones de abazones (*Heteromys nubicolens*), pulgas en ratones de patas rosadas (*Peromyscus mexicanus*), garrapatas en ratones arroceros (*Oligoryzomys fulvescens*) así como también en ratones de patas rosadas. Encontré ácaros amarillos en ratones de patas rosadas, rata trepadora (*Tylomys watsoni*) y ratones de abazones. Los ácaros rojos fueron específicos de ratones arroceros. Los ácaros cafés y tipo pulpo fueron específicos del ratón cantante (*Scotinomys teguina*). El único ratón algodonero híspido (*Sigmodon hispidus*) que atrapé no tenía ectoparásitos. La presencia de pseudoescorpiones en uno de los ratones de abazones introduce una nueva variable que podría explicar la especificidad que encontré, al menos parcialmente, por su depredación sobre algunos ectoparásitos. La morfología del pelo de los ratones fue examinada más a fondo, pues podría explicar la especificidad en ciertos casos.

Coevolution is when species interact so closely they influence the evolutionary change in one another (Coevolution, 2009). There are two types of coevolution: mutualistic and competitive. Amongst competitive coevolution, there are two additional types of interactions which are predation and parasitism. Parasitism is when one organism, a parasite, receives benefits by harming but not killing another organism, the host.

In some parasitic relationships, the host and parasite are so integrated that this results in a specialization between specific species of parasites and hosts (Futuyama & Slatkin, 1983). In domesticated animals and humans, the interactions between parasites and their hosts are well documented. Such is an example with microhabitat specialization. Microhabitat specialization is when an organism utilizes a small area that is unique from its larger, surrounding habitat. *Demodex folliculorum*, for example, is a louse that completes its entire life cycle specifically on the human eyelashes (Rather & Hassan, 2014). Other lice, such as the crab louse (*Pthirus pubis*) live on course hair, such as the pubic area, of the human (Flinders & Schweinitz, 2004). These two lice are species specific to humans. They also happen to be incapable of surviving on any other animal. Lice can also be found on rats, along with ticks, mites, and fleas. For example, Mexican Deer Mice are a known rodent species present in Monteverde that are abundant with fleas (Thones, 2016).

This study will attempt to discover if there is species specificity between ectoparasites and their host rats. Species specificity in this study is defined as the prevalence of a certain type of ectoparasite to a specific species of rat. If there is species specificity, I will attempt to discover the mechanism explaining the interaction. I expect that though there will not be solely one species of ectoparasite to each species of rat, there will still be a clear majority of one species of ectoparasite present.

MATERIALS AND METHODS

From 14 November 2017 – 1 December 2017 I had set up eighteen Sherman traps at five different sites, switching sites every 3 – 4 days. The sites were: San Gerardo, Bajo del Tigre, La Calandria, Curi Cancha, and the Monteverde Institute. I placed each trap 3–5 meters apart from one another. Preferred locations were near burrows where rats were expected to nest and flat ground where the traps would be stable. I triggered each trap beforehand by gently pressing on the lever to ensure the trap door would close properly. Afterwards, I placed a tablespoon of bait (a mixture of oats, vanilla, and rice) gently on the lever inside the trap to incite the rats' entry, keeping the front door open. I tied flagging tape to a nearby sturdy object with a number corresponding to the trap to mark its location.

I inspected each trap early the following morning. Traps without rats had the bait replaced while rats that are caught had the following measurements taken.

First, I noted the location and date of when and where the rat was collected. Next, I identified the species of rat with the assistance of Federico. If we were not able to identify the species in the field, a photo of the rat was taken and marked as UNKNOWN #__ to be searched for later.

During this stage, I also noted the sex of the rat, observing for the presence of a scrotum to identify the difference between males and females. If the rat was young it would also be noted as a juvenile. I took the weight of the rat using a 300 gr Pesola with the rat in the bag. The bag was later weighed by itself and deducted from the total weight to determine the rat's weight.

Next, I measured the rat's tail length and hind foot length in millimeters. I also took additional notes about the rat at this point, such as if it had a partial tail or was recaptured. I

inspected the rat for ectoparasites and any fleas, ticks, and mites I obtained were removed with tweezers and placed into a vial containing 70% ethanol.

I snipped the fur of rats that were captured as an indicator of it being processed. I collected the rat fur to be observed later. I released the rats back at the location where they were originally captured. I rinsed all cages that held rats to remove any traces of feces and food before being rebaited. If I was switching sites, I would rinse and clean all eighteen cages thoroughly beforehand.

When I observed the ectoparasites, I placed them in a petri dish with 70% ethanol. I then placed the dish under a dissecting microscope to observe for morphological differences. Rat hairs I collected were also observed under a dissecting microscope in an attempt to understand a possible mechanism for host-parasite specificity. The idea that hair morphology played a part in ectoparasite abundances stemmed from the knowledge that lice inhabited certain areas of the human body depending on hair characteristics (Flinders & Schweinitz, 2004). I noted hair density, thickness, texture, and other traits. The abundance between certain species of ectoparasites and certain species of rats were then calculated.

RESULTS

Using the combined data from Noelle Pruett, Emily Parker, and myself, we caught a total of 48 rats across six rat species (Table 1). The SPM and HCR had less than 50% of the captured rats with ectoparasites (Figure 1). On the other hand, the WCR, PRR, MDM, and ASM had over 50% of the rats captured with some type of ectoparasite present.

Table 1: Table of six rat species caught across all sites. Common name and the corresponding scientific names of each species are listed. The amount of each species captured is also listed, totaling 48 rats. The future reference is how each species will be referred to for the rest of this study.

Common Name	Scientific Name	# caught	Future reference
Mexican Deer Mouse	*Peromyscus mexicanus*	8	MDM
Cloud-dwelling Spiny Pocket Mouse	*Heteromys nubicolens*	33	SPM
Alston's Singing Mouse	*Scotinomys teguina*	1	ASM
Watson's Climbing Rat	*Tylomys watsoni*	1	WCR
Hispid Cotton Rat	*Sigmodon hispidus*	1	HCR
Fulvous Pygmy Rice Rat	*Oligoryzomys fulvescens*	4	PRR

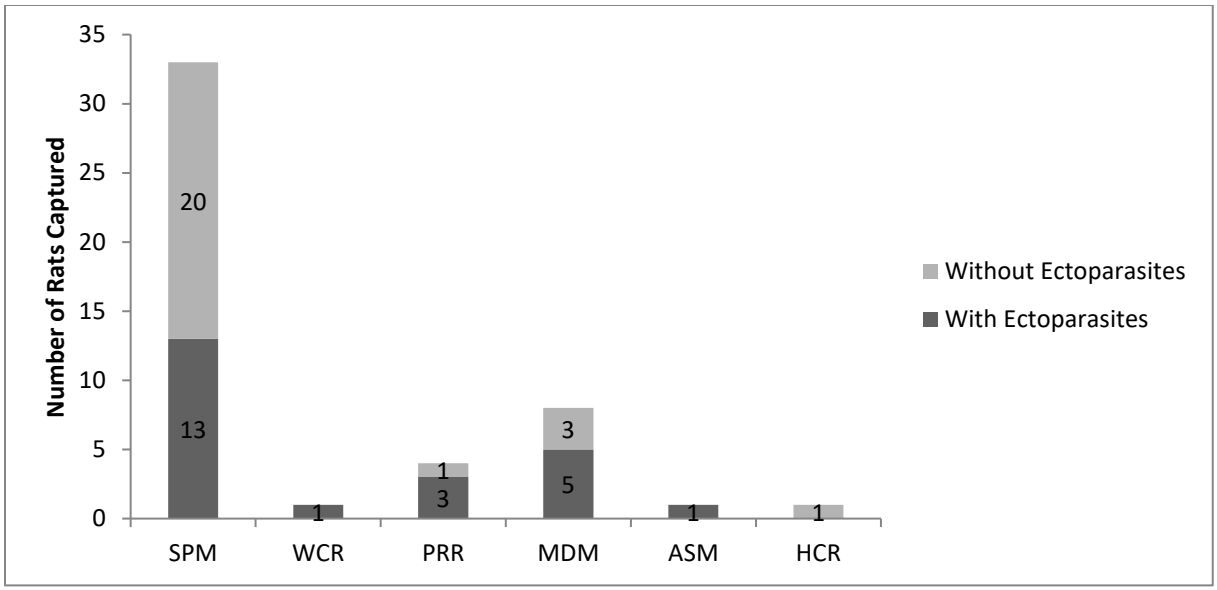

Figure 1: The x-axis represents each species of rat (refer to Table 1). The number in the light grey bar indicates the number of rats caught without ectoparasites, while the dark grey number indicates the number of rats with ectoparasites.

From the rats with ectoparasites, mites were the most abundant ectoparasite present in each species (Figure 2). Ectoparasites on the WCR and ASM were solely mites. MDM showed the largest variation of ectoparasites. Ticks were present on both the PRR and MDM. Fleas were found only on the MDM. One louse was found on one SPM.

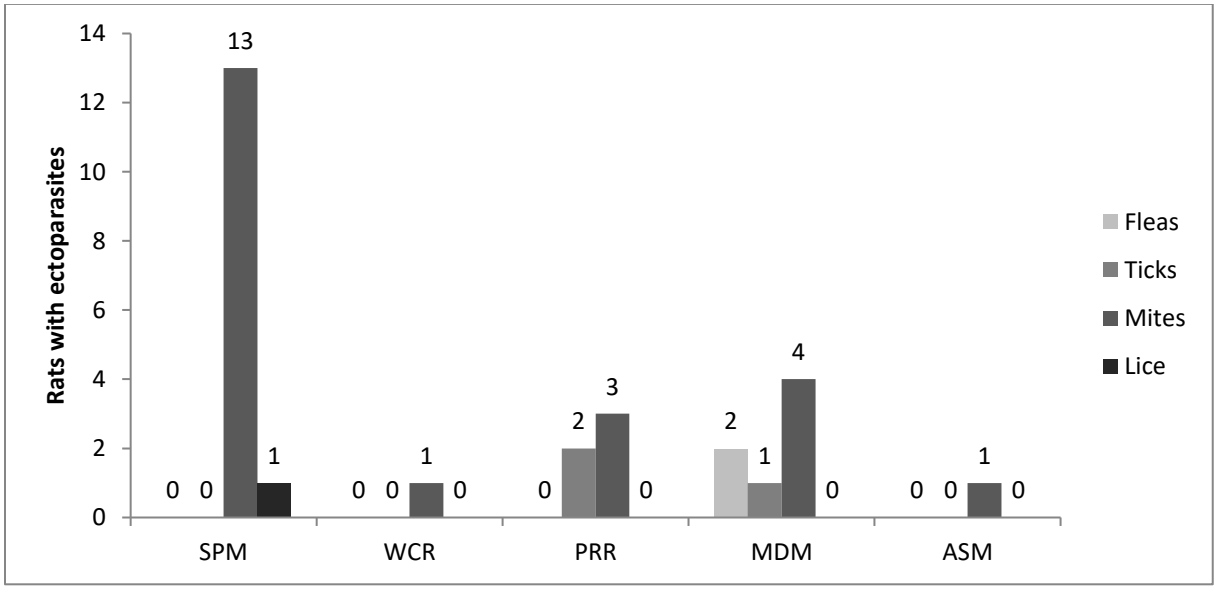

Figure 2: This graph includes only rats with ectoparasites present. A rat individual may be counted more than once if it has more than one type of ectoparasite present. The x-axis represents each species of rat (refer to Table 1). The lightest grey bar indicates the number of rats with fleas. The medium grey bar indicates the number of rats with ticks. The dark grey bar indicates the number of rats with mites. The darkest grey bar indicates the number of rats with lice.

Mites that were collected were further separated into four morphologies: brown mites (Figure 3), red mites (Figure 4), yellow mites (Figure 5), and octopus mites (Figure 6). SPM and WCR had mites which were solely of the yellow morphology (Figure 7). Though MDM had both yellow and red mites present, yellow mites were more prevalent. Red mites were the only mites on the PRR. ASM had mostly brown mites present, with one octopus mite on the ear. Brown mites and octopus mites were found only on the ASM.

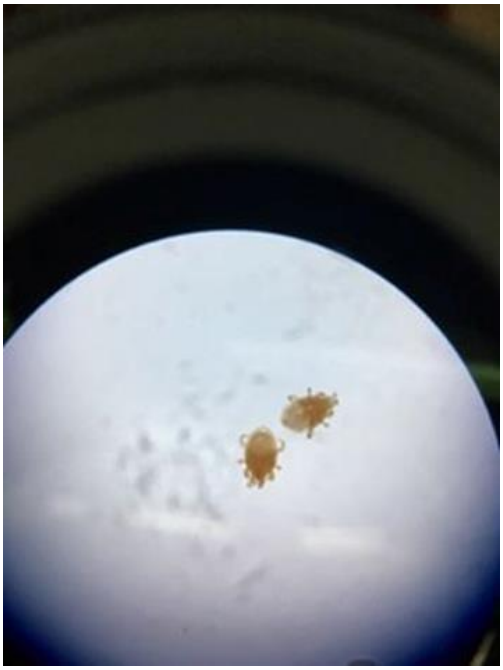

Figure 3: Brown mites viewed from under a dissecting microscope. Mites were <0.5 mm in size. Collected from the base of the Alston's Singing Rat's tail at Curi Cancha.

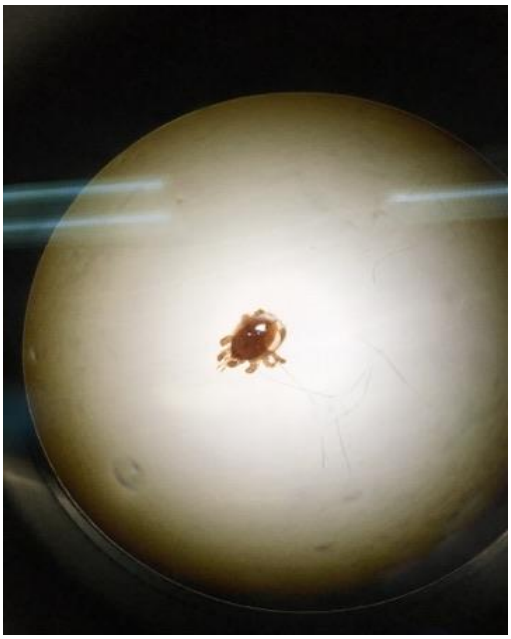

Figure 4: Red mite viewed from under a dissecting microscope. Red mites were about 0.5 mm in size. Collected from the body of the Pygmy Rice Rat at Bajo del Tigre.

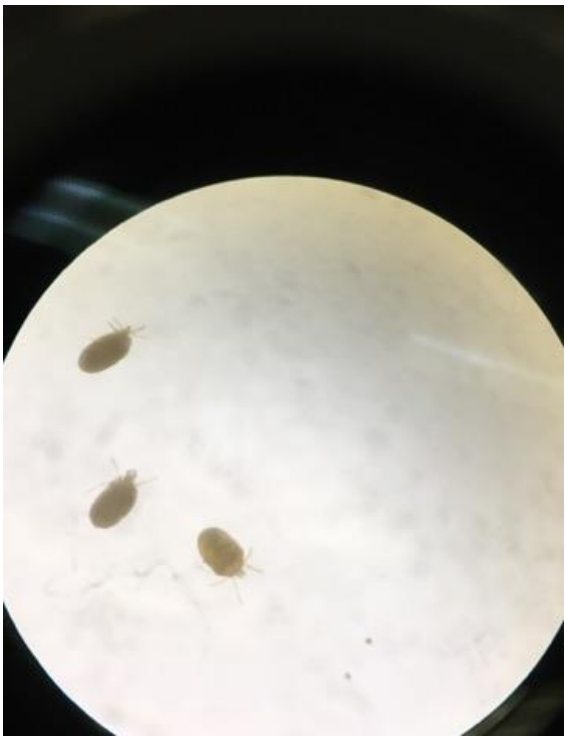

Figure 5: Yellow mites viewed from under a dissecting microscope. Yellow mites were <0.5 mm in size. Collected from the edge of a Spiny Pocket Rat's ears at San Gerardo.

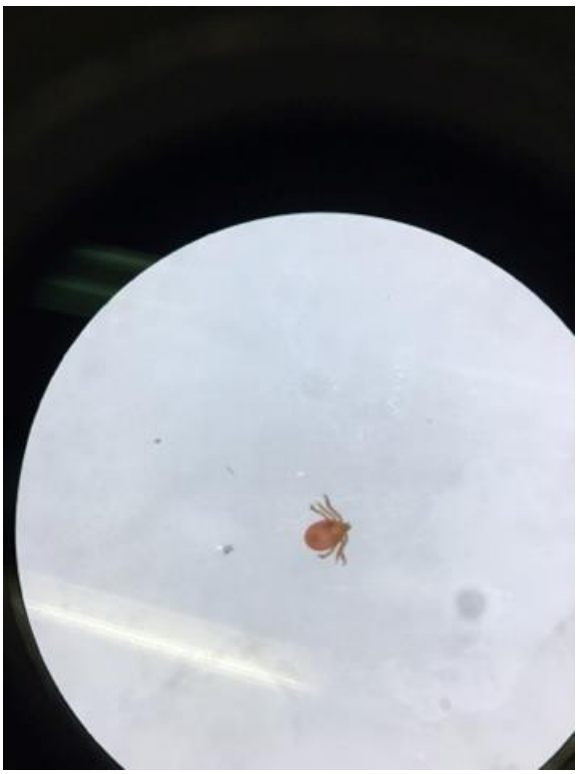

Figure 6: Octopus mite viewed from under a dissecting microscope. Mites were about 0.5 mm in size. Collected from the Alston's Singing Rat's ear at Curi Cancha.

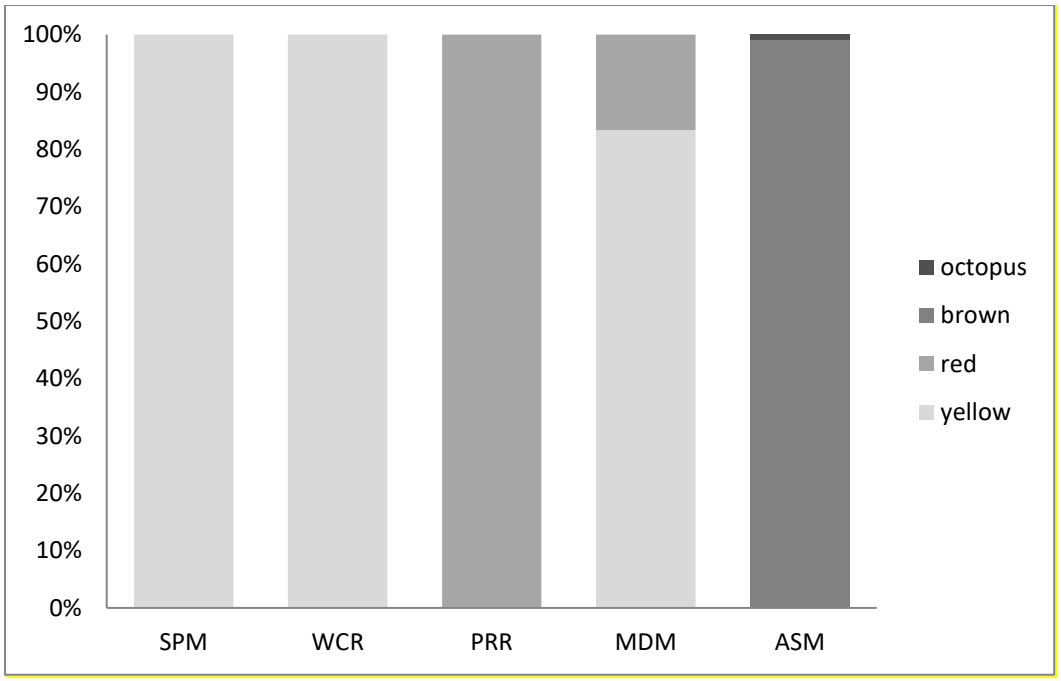

Figure 7: This graph looks at the distribution of mite morphologies in rats with mites. The x-axis represents each species of rat (refer to Table 1). The lightest grey bar indicates the percentage of rats with yellow mites. The medium grey bar indicates the percentage of rats with red mites. The dark grey bar indicates the percentage of rats caught with brown mites. The darkest grey bar indicates the percentage of rats caught with octopus mites.

Furthermore, only one SPM from all 48 rats captured had pseudoscorpions (*Epichernes vickeryae*) (Figure 8). A total of six pseudoscorpions were counted on the single mouse. Pseudoscorpions are not parasites because they prey on ectoparasites.

Figure 8: Adult (left) and juvenile (right) *Epichernes vickeryae* found on a Spiny Pocket Mouse in Bajo del Tigre (n=6). About 2 mm in length.

Hairs of the following rats were also collected: SPM, PRR, MDM, WCR, and HCR. This was in an attempt to determine the mechanism behind any species specificity. ASM hair was not

able to be collected because it escaped before its fur could be snipped. All hairs were viewed under a dissecting microscope at the same magnification.

SPM hair was the thickest of the hairs collected (Figure 9). SPM hair was a combination of spiny and thin. The spiny hairs were easily 3–4 times the thickness of the other hairs. The hair felt rough to the touch and did not clump when placed into the tube with ethanol. PRR hair, in contrast, was the thinnest of the hairs examined (Figure 10). The hair was also shorter and softer. It did not clump when placed in the tube. MDM and WCR hairs were fairly similar in thickness (Figure 11). Both had fur that was soft to the touch. The hairs matted to clumps when collected in the tube but were thin enough to easily separate. The HCR hair was thick, second only to the SPM (Figure 12). The HCR's hair clumped the most, and was extremely difficult to separate once in the ethanol solution.

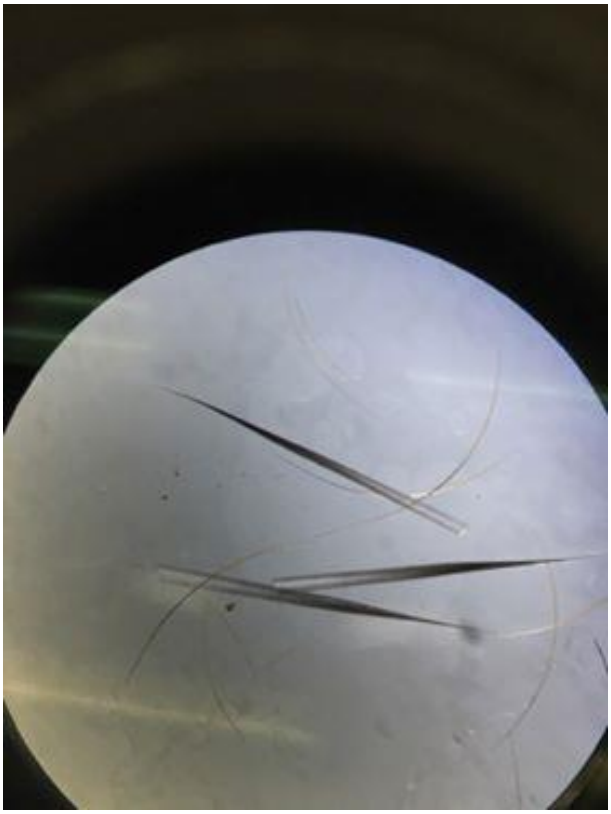

Figure 9: Hair collected from a Cloud-dwelling Spiny Pocket Mouse collected at La Calandria viewed under a dissecting microscope.

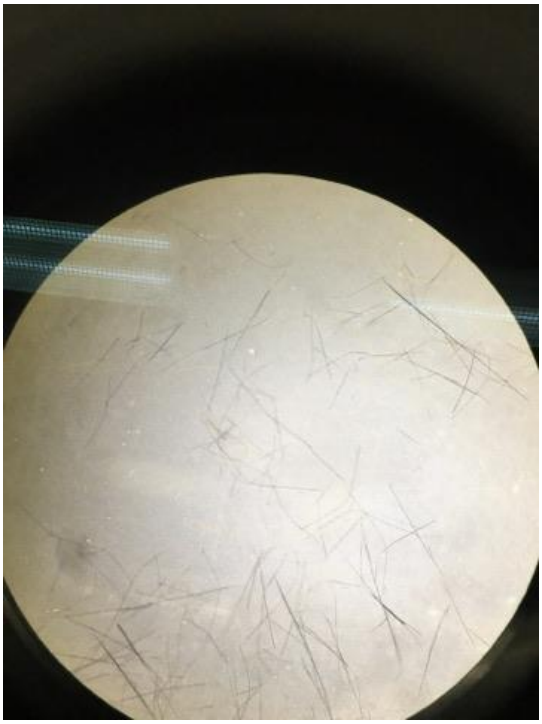

Figure 10: Hair from a Fulvous Pygmy Rice Rat collected at Bajo del Tigre viewed under a dissecting microscope.

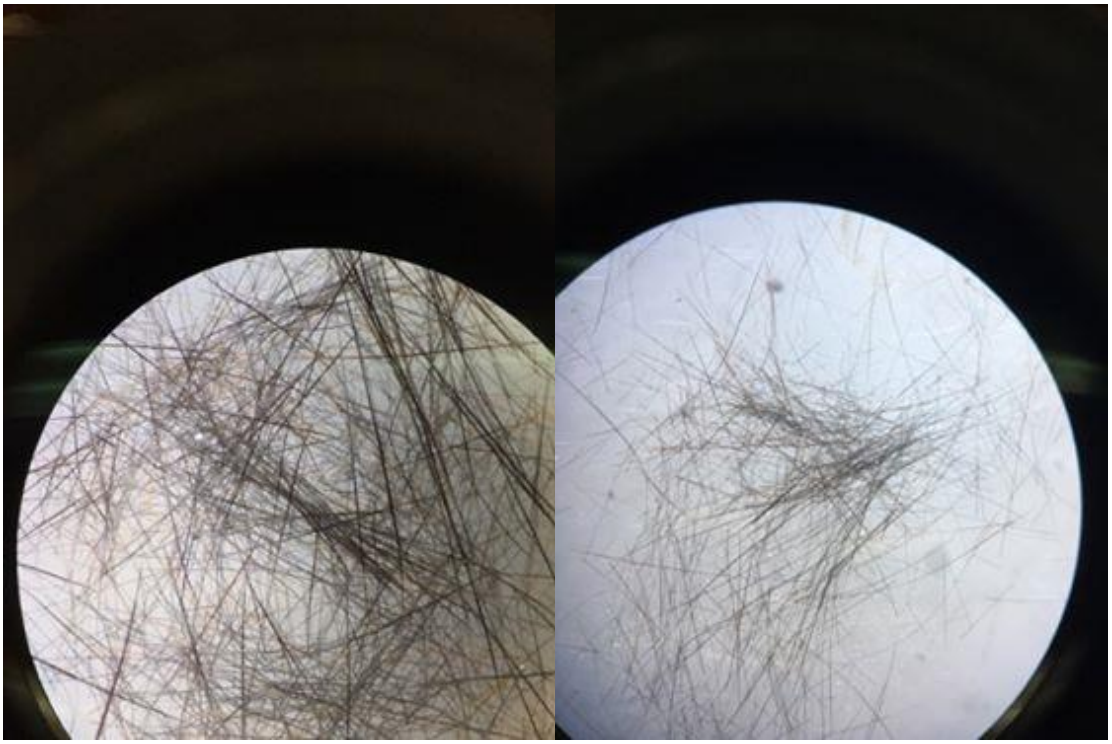

Figure 11: Hair from a Mexican Deer Mice (left) collected from Bajo del Tigre and Watson's Climbing Rat (right) collected from La Calandria viewed under a dissecting microscope.

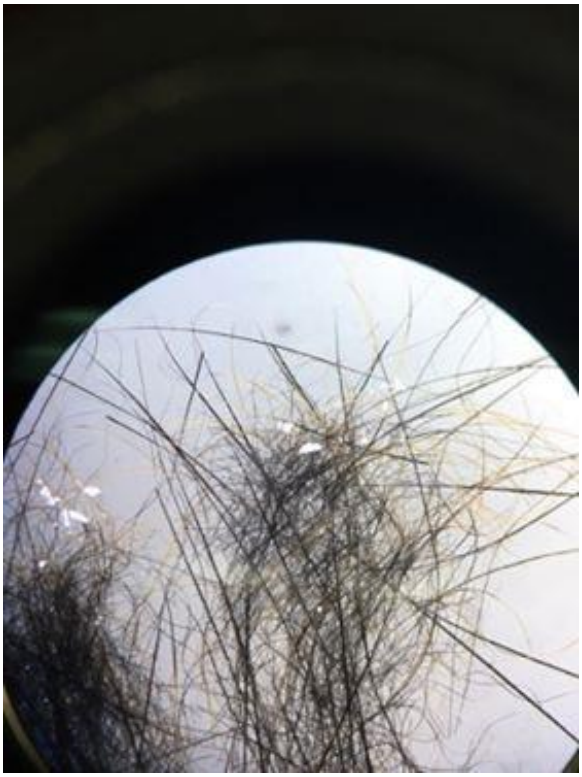

Figure 12: Hair from the Hispid Cotton Rat collected at La Calandria viewed under a dissecting microscope.

DISCUSSION

This data supports my expectation that there is species specificity between ectoparasites and their hosts. Certain species of ectoparasites were more common in some species of rats over others, showing that ectoparasites are found selectively on particular hosts.

Because lice were found present in only the SPM, I have determined that lice are species specific to SPM. Fleas were only found on the MDM, and therefore are specific to MDM. Ticks are specific to both the PRR and the MDM.

There is species specificity for yellow mites in SPM, WCR, and MDM. Though red mites are also present on the MDM, the overwhelming majority of mites found were yellow mites on that species. Red mites are specific to PRR because they are the only type of mite found on that species. ASM introduced two new categories of mites (brown and octopus) that were not present across any of the other five species of rats. Thus, I conclude that both of these are specific to the ASM.

Looking at the data, I tried to determine why SPM had less than 50% of the captured rats with ectoparasites, and of those that had ectoparasites largely had only yellow mites present. This could in part be due to the presence of pseudoscorpions (*Epichernes vickeryae*).

Though *E. vickeryae* were found on only one of the SPM, they could be a reason as to why ectoparasite richness was lower in SPM relative to the other species of rats found. In a study by Lucas Lippert, parasite densities in rats reduced as *Amblyopinus* beetles increased in abundance, an insect which plays a similar role as the *E. vickeryae* in SPM (Lippert, 2001). *E. vickeryae* have a mutualistic relationship with SPM. They can be found in the rats' burrows and consume the ectoparasites in their fur (Francke and Guzman, 2005). The reason why yellow mites were able to prevail may be due to where they are located. Yellow mites stay burrowed

deeply in the rats' ears, whereas the pseudoscorpions were found solely on the rat's fur. This microhabitization can potentially explain why the mites were not preyed upon, though the specific mechanism of interactions between pseudoscorpions and MDM are not well known (Rather & Hassan, 2014). Furthermore, I suspect that like the *Pthirus pubis,* pseudoscorpions could favor the SPM fur over others due to it having the coarsest and thickest hair (Flinders & Schweinitz, 2004).

Looking further into other rat species hairs, I tried to determine a trend between hair morphologies and the types of ectoparasites present on the rats. The PRR hair was very thin, possibly making it easier for ectoparasites to reach its skin and take hold. This is supported by the presence of ticks and red mites (bodily ectoparasites) that were abundant on the PRR. In one mouse, there were a total of 10 ticks on it alone, along with several other ectoparasites. In comparison, the MDM had only three.

Furthermore, the MDM had thicker hair than the PRR or WCR, but thinner hair than the BCR and SPM. This intermediate hair thickness may be able to appeal to a variety of ectoparasites, as the MDM had the greatest diversity of ectoparasites across all six species of rats.

Unfortunately, the ASR fur was not collected, though during the collection of the ectoparasites, its fur was noted to be soft and short. I expect that if we were to collect its fur, its thickness would be similar to the PRR. It also had bodily ectoparasites in the form of brown mites. The WCR, however, challenges this possibility of hair morphology playing a part in species specificity. It, too, has very thin hairs, second only to the PRR of the hairs examined, yet shows no evidence of any bodily ectoparasites.

HCR fur was examined and had the second coarsest hair among the rats. It is possible that due to its texture and tendency to get matted, it prevents ectoparasites from being able go through the fur and reach the skin. Hair morphology playing a role in species specificity, however, is only a hypothesis. Experiments would be needed to test this possibility.

Overall, my results supported my expectation of there being species specificity between parasites and their rodent hosts. This result, however, could have been skewed from a limited sample size. Being able to expand on the number of specimens caught for each rat species would have made this conclusion more solid. Perhaps further studies can expand on the limited knowledge available about pseudoscorpion and rat relationships, thereby increasing our understanding of parasite-host relationships as a whole. Little is known about the mutualistic relationship between *Epichernes vickeryae* and the SPM. Possibly being able to find the mouse burrows where these pseudoscorpions are suspected to reside and observing their interactions could increase our understanding of these creatures.

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