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Differences in Tooth Morphology Between *Sturnira mordax* and *Sturnira hondurensis* Bats

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ABSTRACT

Sturnira spp. are one of the most common genus in Costa Rica as they are frugivorous bats found in middle to high elevations (600m-2600m). With fruit variation comes differences in tooth morphology. There are two *Sturnira* spp. that look quite similar and can be passed as the same species if not given a field guide, as they carry the same field marks in body and fur. *S.mordax* and *S.hondurensis* are small spirited creatures in the *Sturnira* genus that are distinguished through their maxillary and mandibular central incisors. Unfortunately, there aren't many studies when it comes to comparing more characteristics or the sizes of these incisors. I conducted a study of the differences in tooth morphology between *S.mordax* and *S.hondurensis* in Monteverde and San Gerardo. I anticipated for *S.hondurensis* to have larger teeth measurements than *S.mordax* due to the long narrow skull *S.hondurensis* has compared to *S.mordax*. I went to four different sites (Monteverde Estacion Biologica, LIFE Farm, Monteverde Institute, and the Children's Eternal Rainforest) and installed three mist-nets for each site. I collected a total of 36 *Sturnira* bats and found no significant difference in tooth morphology between *S.mordax* and *S.hondurensis*. This could be due to attrition or hybridization of these two species.

RESUMEN

Diferencias en la morfología de los dientes entre los murciélagos *Sturnira mordax* y *Sturnira hondurensis*

Los murciélagos *Sturnira* spp. son uno de los géneros más comunes en Costa Rica ya que son murciélagos frugívoros que se encuentran en elevaciones medias y altas. La variación de los frutos conlleva diferencias en la morfología de los dientes. Hay dos *Sturnira* spp. que son bastante similares y pueden pasar por la misma especie sin una guía de campo presente, ya que tienen las mismas características en el cuerpo y el pelaje. *S.mordax* y *S.hondurensis* se distinguen por sus incisivos centrales maxilares y mandibulares. Lamentablemente no existen muchos estudios al comparar más características o los tamaños de estos incisivos. Llevé a cabo un estudio de las diferencias en la morfología dental entre *S.mordax* y *S.hondurensis* en Monteverde y San Gerardo. Anticipé que *S.hondurensis* tendría dientes más grandes que *S. mordax* debido al cráneo largo y estrecho que *S.hondurensis* tiene en comparación con *S.mordax*. Fui a cuatro sitios diferentes e instalé tres redes de niebla durante cada sitio en las noches. Recolecté un total de 36 murciélagos *Sturnira* y no encontré diferencias significativas en la morfología de los dientes entre *S.mordax* y *S.hondurensis*. Esto podría deberse al desgaste de los dientes o la hibridación de ambas especies en los murciélagos.

Introduction

In the tropics, it is simple to encounter bats in the Phyllostomidae family, one genus being *Sturnira*. These native bats can appear in different shades and sizes. *S.mordax* and *S.hondurensis* can range from medium to dark brown with reddish patches on shoulders. Incorporating tooth morphologies as a primary field mark is important since these two *Sturnira* spp. are commonly confused. *S.mordax* and *S.hondurensis* both have mandibular bilobed incisors. However, *S.mordax* has maxillary central incisors that are bilobed, blunt, with converging tips whereas *S.hondurensis* has maxillary central incisors that are unicuspid, pointed, with

diverging tips¹. In Costa Rica, these species are found in (600m-2600m)² ; however, they can also be found in Panama and in disturbed habitats on the Caribbean slope³. *S.hondurensis* is another species that is quite similar to *S.mordax* as it also ranges from medium to dark brown with reddish patches on shoulders, ranging from Northern Mexico to Guyana and Ecuador³. For the longest time, tropical bats have consumed fruit, nectar, and pollen. The *Sturnira* genera, for example, includes fruit in their diets. Depending on the morphology of the species, these fruits can range from soft or even hard fruits along with insects. *S.mordax* & *S.mordax* consume from 22-29 different kinds of fruit dominated by *Pier*, *Solanum*, *Pothomorphe*, *Muceace*, *Xanthosoma*, etc².

As we know bats are mobile, because of this, consuming fruits has supplied a great ecosystemic service. These small creatures have facilitated land restoration and plant dispersal since they spread seeds by dropping their fruit once finished. However, if it weren't for the incisors that they have, maybe *Sturnira* bats would not contribute to biodiversity at all.

Teeth morphology and function are factors that play important roles in understanding bat behavior. Unfortunately, these critical factors have been understudied. These characteristics can provide information as far as how solid and robust the fruits are that *Sturnira* bats eat. It is important to collect teeth measurements (width: length) of both males and females to obtain a better

understanding of my question: How does tooth morphology vary between *Sturnira mordax* and *hondurensis* in Monteverde and San Gerardo? This study is based on two different species of bats with the same dental formula (heterodont) (I 2/2, C 1/1, P 2/2, M 3/3 = 32)⁹ representing one genera (*Sturnira*), one family (Phyllostomidae), and one subfamily (Stenodermatinae). These were the selected species for this research since they are the most prominent at middle to high elevations. I hypothesize *S.hondurensis* to have larger teeth measurements than *S.mordax* because *S.hondurensis* have a long narrow skull allowing them to have more space for longer teeth⁷ whereas, *S.mordax* have a short snout giving less space for long teeth⁵.

MATERIALS AND METHODS

I conducted a study between the dates of 13-29 November 2023 at the Monteverde Biological Estacion, Monteverde Institute, LIFE Farm, and the Children's Eternal Rainforest where I set up three mist-nets and captured *Sturnira* bats. Overall, I was able to collect six days worth of data/ images for *S.hondurensis* and *S.mordax*. I imported those images into *Image J* where I analyzed and measured the length and width of the upper and lower incisors. I then used a t-test to compare forearm length, teeth width, and length of *S.hondurensis* and *S.mordax* to see if there is a significant difference in their sizes.

Throughout this time, I captured 36 *Sturnira* bats combined. In every single site, with help, I was able to set up three different mist-nets in different areas. Because *Sturnira* spp. are frugivorous bats, the idea was to set them near trees that contained fruit such as, Museace, and Piperaceae. Conducting this experiment in Monteverde and San Gerardo also meant species variation due to the high elevations we were in. Once mist-nets were set up, every evening around 6pm I began my rounds of checking the nets every 15-30 minutes. Depending on the night, we checked each net around four to five times before we called it for the night. During the task of collecting these creatures and processing them, we used latex and hardware gloves to move the bats from the nets, to cloth bags. I measured the weight of the bat in the cloth bag and subtracted

the weight of the bag afterward. The next step was measuring the forearm of the bat with a caliper. This was an important part in data collecting as its one determining factor in identifying an *S.hondurensis* vs *S.mordax*. By extending the bats' wings and flashing a light through one of their bone fingers, I was able to determine the age of these *Sturnira* bats. If the light did not go through the bone and fused, that bat would be an adult. However, if the light went through, the bat would be considered juvenile as its bone isn't fully developed. Through their genitalia, I was able to determine whether the *Sturnira* bat was a male or female. In addition to forearm measurements, in order to classify a *Sturnira* species from *S.hondurensis* or *S.mordax*, understanding the different tooth morphologies between the two are vital. As mentioned previously, if the upper central incisors are bilobed, blunt, and with diverging tips, the species would be *S.hondurensis*. If the upper central incisors are unicuspid and appear pointed with converging tips, the species would be *Mordax*. For both species, the mandibular central incisors are bilobed. With a magnifying lens, I took pictures and videos of both the maxillary and mandibular central incisors to measure them on my computer. Through Image J, I uploaded the images, set the scale to 24mm (the diameter of the magnifying lens) and measured the length and width of both upper and lower central incisors.

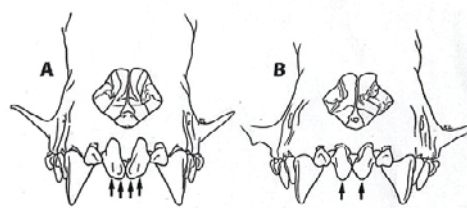


Figure A: Figure A. Maxillary Incisors of *S.mordax* (A) and *S.hondurensis* (B).

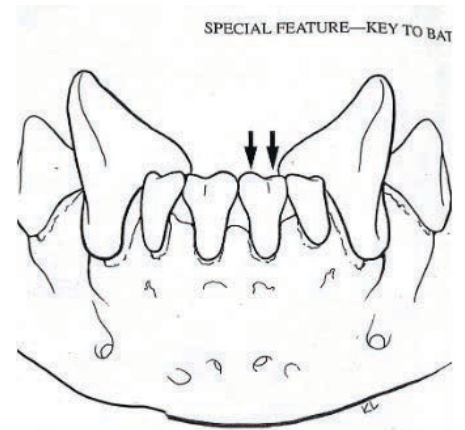


Figure B: Mandibular Incisors of *S.mordax* and *S.hondurensis*.

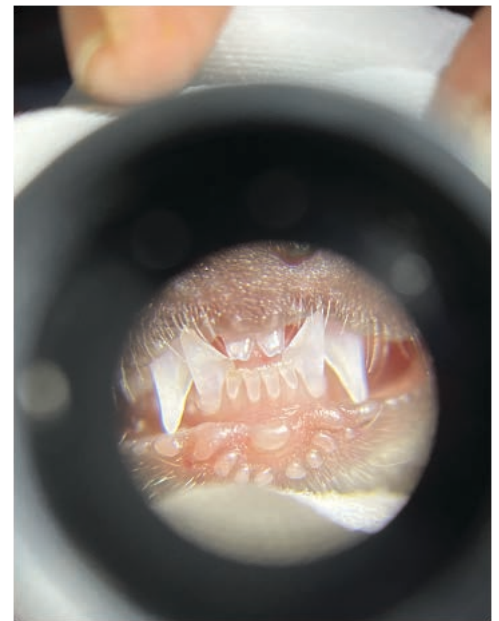


Figure C: Image of *S.mordax* incisors through a magnifying lens.

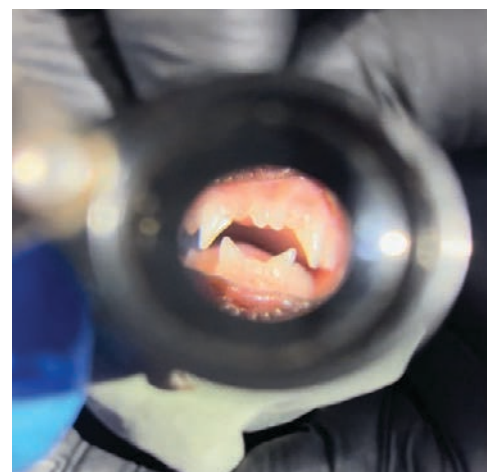


Figure D: Image of *S.hondurensis* incisors through a magnifying lens.

Results

I captured a total of 36 *Sturnira* Bats, 13 male *S.hondurensis*, 20 female *S.hondurensis*, 2 male *S.mordax*, and 2 female *S.parvidens*. From the graphs that I developed, we are able to observe some differences in maxillary central incisor measurements (Maxillary Average in Length (mm) (M,H,P): 1.47, 1.69, 1.765) (Maxillary Average in Width (mm) (M,H,P): 1.02, 1.17, 0.99) (Figure 1 and 2). During the processing of *S.hondurensis* vs. *S.mordax* I approached an intriguing yet challenging factor that changed my trajectory with my research. What I thought to believe was a *S.mordax*, was actually a *S.hondurensis*. The reason for this was in the forearm measurements. In the field key to bats from Costa Rica, the forearm measurements for a *S.hondurensis* range from 42-46 mm whereas for a *S.mordax*, it ranges from 44-49 mm¹¹. Because the tooth morphologies between these two species can be very similar at times, turning to the field key for a second opinion is important; and when you have an adult *Sturnira* bat that has a 40.7 mm forearm, you can't identify it as *S.mordax*. After processing this bat, I encountered similar situations with other *Sturnira* bats in which they had unicuspid diverging tips like a *S.hondurensis*; however the forearm measurements fell into the range of a *S.mordax*. Since these two species come from the same genera, the close proximity in values are expected therefore, I decided to develop independent one-tailed T-tests between *S.mordax* and *S.hondurensis* in length and width for maxillary central incisors (maxillary length $p = 0.31$ | maxillary width $p = 0.07$). When we observe the measurements for mandibular central incisors for both species (Figure 3 and 4), we instantly see smaller values since the mesiodistal dimension (width) is smaller with labial fan-shaped crowns (maxillary incisors have palatal tooth surfaces)⁶. These different values in measurements lead us to different results in T-tests (mandibular length $p = 0.13$ | mandibular width $p = 0.39$). As mentioned previously, forearm measurement is an important factor in helping determine the species of a *Sturnira* bat. By analyzing the graph (Figure 5), there seems to be no difference between the forearm sizes in *S.mordax* and *S.hondurensis*. With an independent one-tailed T-test, we get a p-value of $p = 0.47$.

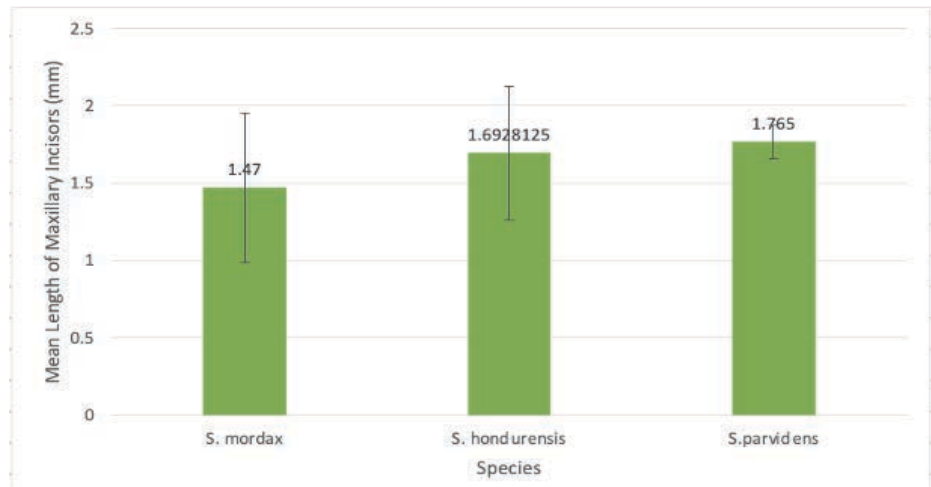


Figure 1. Maxillary Incisor Length | (*S.mordax* vs. *S.hondurensis*) | no significant difference)

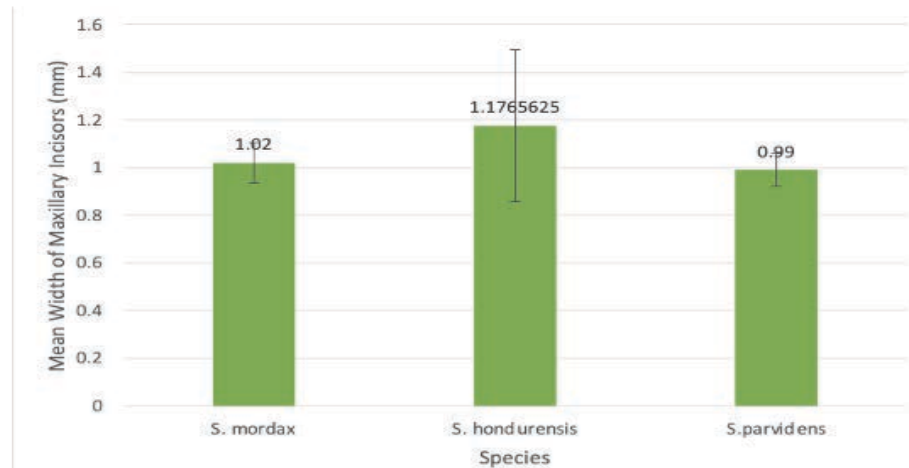


Figure 2. Maxillary Incisor Width | (*S.mordax* vs. *S.hondurensis*) | no significant difference)

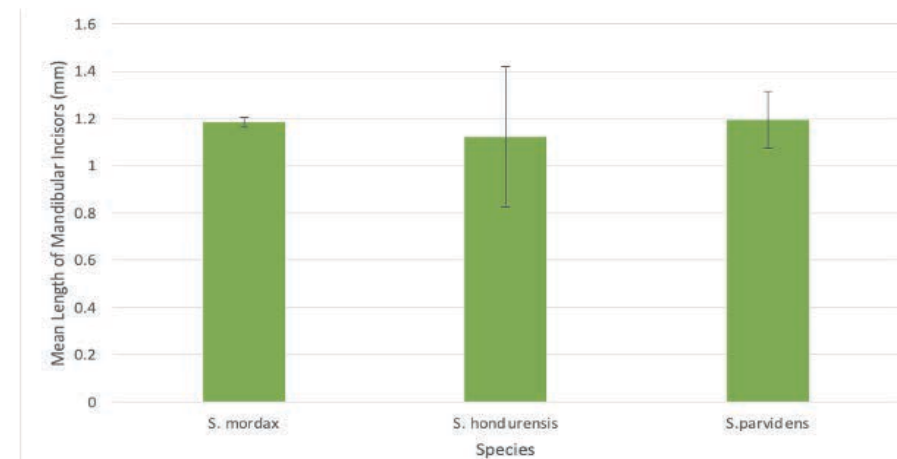


Figure 3. Mandibular Incisor Length | (*S.mordax* vs. *S.hondurensis*) | no significant difference)

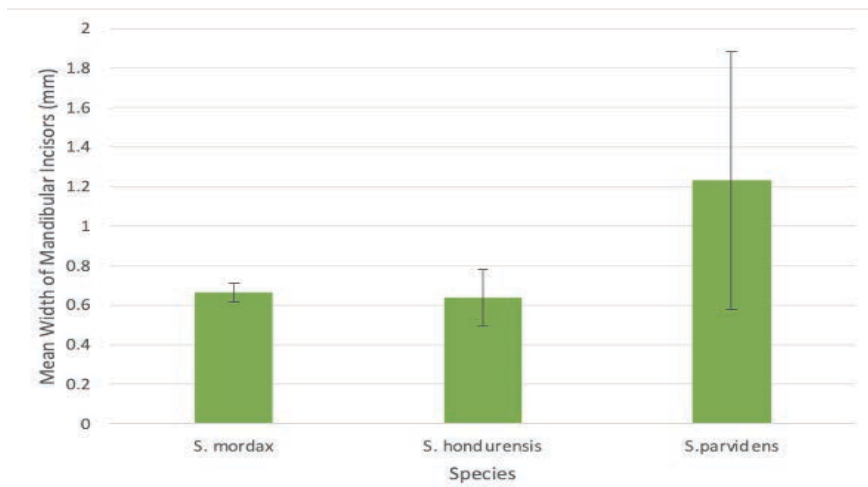


Figure 4. Mandibular Incisor Width | (*S.mordax* vs. *S.hondurensis* | no significant difference)

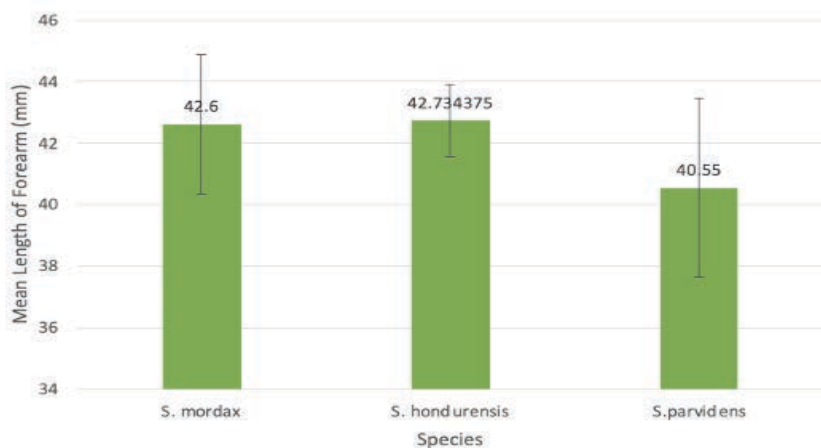


Figure 5. Forearm Incisor Length | (*S.mordax* vs. *S.hondurensis* | no significant difference)

Discussion

This study suggests that *S.mordax* and *S.hondurensis* aren't as different as we may think. My result could be due to the small number of *S.mordax* bats collected compared to *S.hondurensis* (33 *S.hondurensis*, 2 *S.mordax*). I did not foresee the effect climate change (rainfall/ El Niño) could have on species abundance in my predictions; this created an impact in my study. I might have also been closer to middle elevations than higher ones. Perhaps, with these details not being an issue, my averages would be different and my p-values would show a significant difference. This wouldn't be the case for *S.parvidens* as it is effortless to differentiate with its trilobed mandibular central incisors and small forearm length (< 41mm). Until then,

although tooth morphologies of *S.mordax* and *S.hondurensis* can be distinguishable at times, the forearm and central incisor measurements are not significantly different (Figures 1-5). This is not surprising as these two species come from the same genera. However, what explains the intertwining of forearm sizes and tooth morphologies between *S.mordax* and *S.hondurensis*?

From my knowledge, there has not been any research answering this but, tooth attrition and bat hybridization are proposals that come to mind. Teeth wear out overtime. Surely, these creatures have encountered fruits both unripe and/ or ripe that have flattened their incisors overtime due to attrition⁸. If this is the case, there could be many *S.mordax* bats with unicuspid maxillary incisors at high

elevations (where *S.mordax* are found to be the most abundant) that appear as *S.hondurensis* especially, if their forearm size overlaps (*S.mordax*: 44-49mm | *S.hondurensis*: 42-46mm). This doesn't mean it wouldn't apply to *S.hondurensis* because it would but, it would be more prominent on *S.mordax* bats since they would lose their most valuable field mark; the maxillary bilobed central incisors. This idea of course might not apply to a *Sturnira* bat that is juvenile as its permanent teeth emerge later on³ and it has not faced attrition. Interbreeding with different species is a possibility with bats⁴. With the *Punnett Square* stating all of the possible outcomes for a genetic cross between two individuals with known genotypes¹⁰, perhaps some *S.hondurensis* bats obtained maxillary bilobed central incisors (*S.mordax* characteristic) and kept their generic forearm length. If interbreeding occurs with other groups of mammals, why wouldn't it happen with Chiroptera? Ultimately, in this study, there wasn't much variation in teeth morphology as I expected. To have a definitive understanding of the variation between the tooth morphology with these two species, I do recommend future research to be conducted. This study would reveal the evolutionary, molecular and ecological significance of bat hybridization and dental morphology in *S.mordax* and *S.hondurensis* bats.

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APPENDIX

Table A: Raw data of *Sturnira* forearm lengths, sex, age, and teeth measurements.

Day 1 (11/13): Estacion Biologica							
#	species	sex	teeth measu	teeth measu	age	uni/bi/tri	forearm (mm)
1	<i>Hondurensis</i>	F	1.99:1.32	1.25:0.79	adult	bottom bilo	42
2	<i>Hondurensis</i>	F	2.13:1.17	1.15:0.51	adult	bottom bilo	42.2
3	<i>Mordax</i>	M	1.13:1.08	1.17:0.63	juvenile	upper bilobe	41
4	<i>Hondurensis</i>	M	2.42:1.64	1.02:0.81	juvenile	bottom bilo	41
5	<i>Hondurensis</i>	M	2.15:1.67	1.50:0.78	adult	bottom bilo	43
6	<i>Hondurensis</i>	F	2.27:1.67	1.66:0.78	adult	bottom bilo	43.8
7	<i>Hondurensis</i>	F	1.66:1.32	1.50:0.76	adult	bottom bilo	43
Day 3 (11/20): LIFE Farm							
#	species	sex	teeth measu	teeth measu	age	uni/bi/tri	forearm (mm)
1	<i>Parvidens</i>	F	1.84:1.04	1.28:0.77	juvenile	bottom trilc	38.5
2	<i>Parvidens</i>	F	1.69:0.94	1.11:0.69	sub adult	bottom trilc	42.6
Day 5 (11/28): CER							
#	species	sex	teeth measu	teeth measu	age	uni/bi/tri	forearm (mm)
1	<i>Mordax</i>	M	1.81:0.96	1.20:0.70	A	upper conve	44.2
2	<i>Hondurensis</i>	M	1.74:1.34	1.34:0.58	A	uni	43.2
3	<i>Hondurensis</i>	F	1.69:1.15	0.90:0.61	A	uni	44.3
4	<i>Hondurensis</i>	F	1.76:0.84	0.77:0.52	A	uni	44.4
5	<i>Hondurensis</i>	F	1.32:1.10	0.99:0.62	A	uni	42.6
6	<i>Hondurensis</i>	M	1.61:0.86	0.76:0.54	A	uni	41.1
7	<i>Hondurensis</i>	F	1.52:0.88	0.77:0.48	A	uni	43.5
8	<i>Hondurensis</i>	M	2.18:1.08	1.19:0.73	A	uni	43.4
9	<i>Hondurensis</i>	M	1.20:0.84	0.80:0.54	A	uni	42.3
10	<i>Hondurensis</i>	F	1.11:0.68	0.69:0.35	A	uni	41

Day 2 (11/14): Estacion Biologica							
#	species	sex	teeth measu	teeth measu	age	uni/bi/tri	forearm
1	<i>Hondurnesi</i>	F	1.01: 0.81	1.12: 0.60	sub adult	bottom bilo	42
2	<i>Hondurnesi</i>	F	2.36: 1.46	1.58: 0.84	adult	bottom bilo	44
3	<i>Hondurnesi</i>	F	2.01: 1.51	0.98: 0.83	adult	bottom bilo	44
Day 4 (11/23): Monteverde Institute							
#	species	sex	teeth measu	teeth measu	age	uni/bi/tri	forearm (mm)
1	<i>Hondurensi</i>	M	1.33: 1.84	1.49: 0.78	juvenile	bottom bilo	44.2
Day 6 (11/29): CER							
#	species	sex	teeth measu	teeth measu	age	uni/bi/tri	forearm (mm)
1	<i>Hondurensi</i>	F	1.62:1.34	1.30:0.58	A	uni	42
2	<i>Hondurensi</i>	F	1.57: 1.15	0.80:0.61	A	uni	43.3
3	<i>Hondurensi</i>	F	1.67:0.84	0.97:0.52	A	uni	40.7
4	<i>Hondurensi</i>	F	1.38:1.10	0.89:0.62	A	uni	44.1
5	<i>Hondurensi</i>	F	1.75:0.86	0.76:0.54	A	uni	41.6
6	<i>Hondurensi</i>	F	1.59: 0.88	0.77:0.48	A	uni	41
7	<i>Hondurensi</i>	F	1.67:1.08	0.69:0.73	A	uni	43.6
8	<i>Hondurensi</i>	F	2.05:0.84	0.72:0.54	A	uni	42.5
9	<i>Hondurensi</i>	F	1.21:0.68	0.63:0.35	A	uni	44.7
10	<i>Hondurensi</i>	F	2.15: 1.67	1.50: 0.78	A	uni	41.9
11	<i>Hondurensi</i>	F	2.27: 1.67	1.66: 0.78	A	uni	43.1
12	<i>Hondurensi</i>	F	1.66: 1.32	1.50: 0.76	A	uni	44.2
13	<i>Hondurensi</i>	F	2.36: 1.46	1.58: 0.84	A	uni	43