MORPHOLOGICAL RESPONSE IN SISTER TAXA OF WOODRATS (GENUS: *NEOTOMA*) ACROSS A ZONE OF SECONDARY CONTACT

A Thesis

presented to

the Faculty of California Polytechnic State University,

San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Biology

by

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September 2015

COMMITTEE MEMBERSHIP

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ABSTRACT

Morphological Response in Sister Taxa of Woodrats (Genus: *Neotoma*) Across A Zone Of Secondary Contact

Michaela Maria Koenig

This study focuses on a secondary contact zone between two sister species of woodrat, *Neotoma fuscipes* (dusky-footed woodrat) and *N. macrotis* (big-eared woodrat). Along the Nacimiento River, on the border of southern Monterey and northern San Luis Obispo counties, the ranges of these sister species of woodrats meet and overlap forming a secondary contact zone. The zone of secondary contact is estimated to include a 500-meter (~1,650 linear feet) portion of the Nacimiento River riparian corridor.

This research examines quantifiable morphological change that is likely associated with heightened inter-specific competition within the contact zone. When in sympatry the sister species may compete for resources indirectly through exploitative competition, or directly through contest competition, or through a combination of these two processes. The prediction that heightened competition has resulted in distinctive morphological character shifts between allopatric and sympatric populations was tested my examining size and shape of adult woodrats along a 20-kilometer transect. It was confirmed that adults woodrats of the two sister taxa are morphologically distinct (N = 607) and that the phallus morphology was indeed a reliable means to identify adult male woodrats as to species ($p < 0.0001$, N = 331). A two model approach was used to examine convergence and divergence in size and shape of woodrats across the transect. *Neotoma fuscipes* exhibited a statistically significant divergerence from *N. macrotis* with regard to breadth of rostrum ($p < 0.0001$, N = 414) in a region of sympatry along the Nacimiento River. Based on the results on one statistical model, *N. macrotis* exhibited a statistically significant convergence with regard to body-size ($p = 0.0240$, N = 587) and length of hind foot ($p < 0.0001$, N = 563) towards those of *N. fuscipes* between zones of sympatry and allopatry. Alternatively, based on the results of a second statistical model that accounted for environmental variation within the system both species exhibited a statistically significant divergence with regard to body-size ($p = 0.0054$, N = 587) and towards that of *N. fuscipes* between zones of sympatry and allopatry. Also, *N. macrotis* exhibited a statistically significant convergence with regard to length of ear ($p = 0.0022$, N = 563) towards that of *N. fuscipes*. Based on the results of both models, detectable re-patterning of size-independent traits was observed to varying degrees.

The morphological character shifts between sympatric populations and allopatric populations of woodrats suggest that ecological interactions between the species are occuring. Specifically, across the contact zone, patterns of variation in body-size and other morphological character traits are consistent with expectations of a combination of contest and exploitative competition.

Keywords: sympatry, allopatry, allometry, hybrid, congener, convergence, divergence, contest competition, exploitative competition, character displacement.

ACKNOWLEDGMENTS

For assistance in the field I thank J. Bender, S. Snyder, W. Knowlton, S. Widin, C. Faurot-Daniels, L. Anderson, A. Estacio, P. Murphy, M. Gritts, J. Crawford, R.J. Feldman, and the Cromer boys. I thank the staff and administration, especially M. Moore, P. Farrell, and M. Williams, of the Camp Roberts Military Reservation for granting access to the premises and facilities, and for granting me access to the latrine in Sherwood Forest. Thank you to Robert Stafford, with California Department of Fish and Wildlife, for granting me access to Big Sandy Wildlife Area. Thank you to Brent Bueche, with Monterey County Water Resource Agencies, for granting me access to property below Nacimiento Dam. Funding for this research was provided in part by a National Science Foundation grant (DEB-0952946) to M.D Matocq, the Department of Natural Resources and Environmental Science at the University of Nevada, Reno, and the Department of Biological Science at California Polytechnic State University, San Luis Obispo. I would especially like to thank my committee members, Dr. Andrew Schaffner, Dr. Scott Steinmaus, and Dr. Francis Villablanca from California Polytechnic University, San Luis Obispo and Dr. Marjorie Matocq of the University of Nevada, Reno. This project would not have been possible without the support of Dr. Marjorie Matocq and Dr. Peter Murphy of the University of Nevada, Reno. I would like to dedicate this endeavor to my nieces and nephews: may you always follow your dreams and may those dreams be as big as the galaxy!

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INTRODUCTION

Areas of secondary contact between sister lineages provide a unique opportunity to understand the mechanisms that contribute to the generation and maintenance of species boundaries. Woodrats of the genus *Neotoma,* and more specifically, of the sister lineages *N. fuscipes* and *N. macrotis,* provide a system in which to examine how ecological, behavioral, and morphological isolating mechanisms may contribute to the genetic or phenotypic distinctiveness within and between species. Biologists have long recognized that areas of secondary contact and hybridization are natural laboratories for evolutionary studies (Hewitt 1988), which provide windows into the evolutionary process (Harrison 1990), divergence and speciation (Harrison 1993; Butlin et al. 1998; Shurtliff et al. 2014), and the consequences of these processes. By quantifying morphological character shifts between sympatric populations and allopatric populations, we have an opportunity to examine how intr-specific interactions may influence the evolutionary process.

Dusky-footed (*N. fuscipes*) and big-eared (*N. macrotis*) woodrats are sigmodontine rodents (Family: Cricetidae) that typically inhabit coastal scrub, riparian habitat, and oak woodlands of the west coast of North America (McEachern et al. 2009). They are known for constructing and inhabiting large, multi-chambered stick houses known as middens (Carraway and Verts 1991). Woodrats are nocturnal, semi-arboreal rodents that are active all year round. Dusky-footed and big-eared woodrats rely on their middens for protection and food storage (Carraway and Verts 1991). *Neotoma macrotis* was previously characterized as a subspecies (*N. fuscipes macrotis*) in the *N. fuscipes* species complex. Matocq (2002a) elevated the subspecies *N. fuscipes macrotis* to full species

status as *N. macrotis* (the big-eared woodrat). This elevation was based on mitochondrial haplotypes that fell into two highly divergent clades (Matocq 2002b) and split *N.f. macrotis* from *N.f. sensu stricto*. Currently, it is recognized that the two sister taxa are highly differentiated genetically and morphologically (∼10% cytochrome *b* divergence) (Matocq 2002a, 2002b). The subspecies *N.f. bullatior* and *N.f. monochroura*, *N.f. fuscipes*, *N.f. streatori*, *N.f. annectens*, *N.f. riparia* and *N.f. perplexa* were retained as subspecies of the dusky-footed woodrat complex. While the southern subspecies were classified in the big-eared woodrat (*N. macrotis*) complex as *N.m. luciana*, *N.m. macrotis*, *N.m. martirensis* and simplex (Figure 1). The genetic findings corresponded with distinctive variation in body-size, craniodental morphology, and specialized external phallus morphology (“oblong” versus “flower-like”), thereby corroborating that these two clades were indeed distinct species (Matocq 2002a).

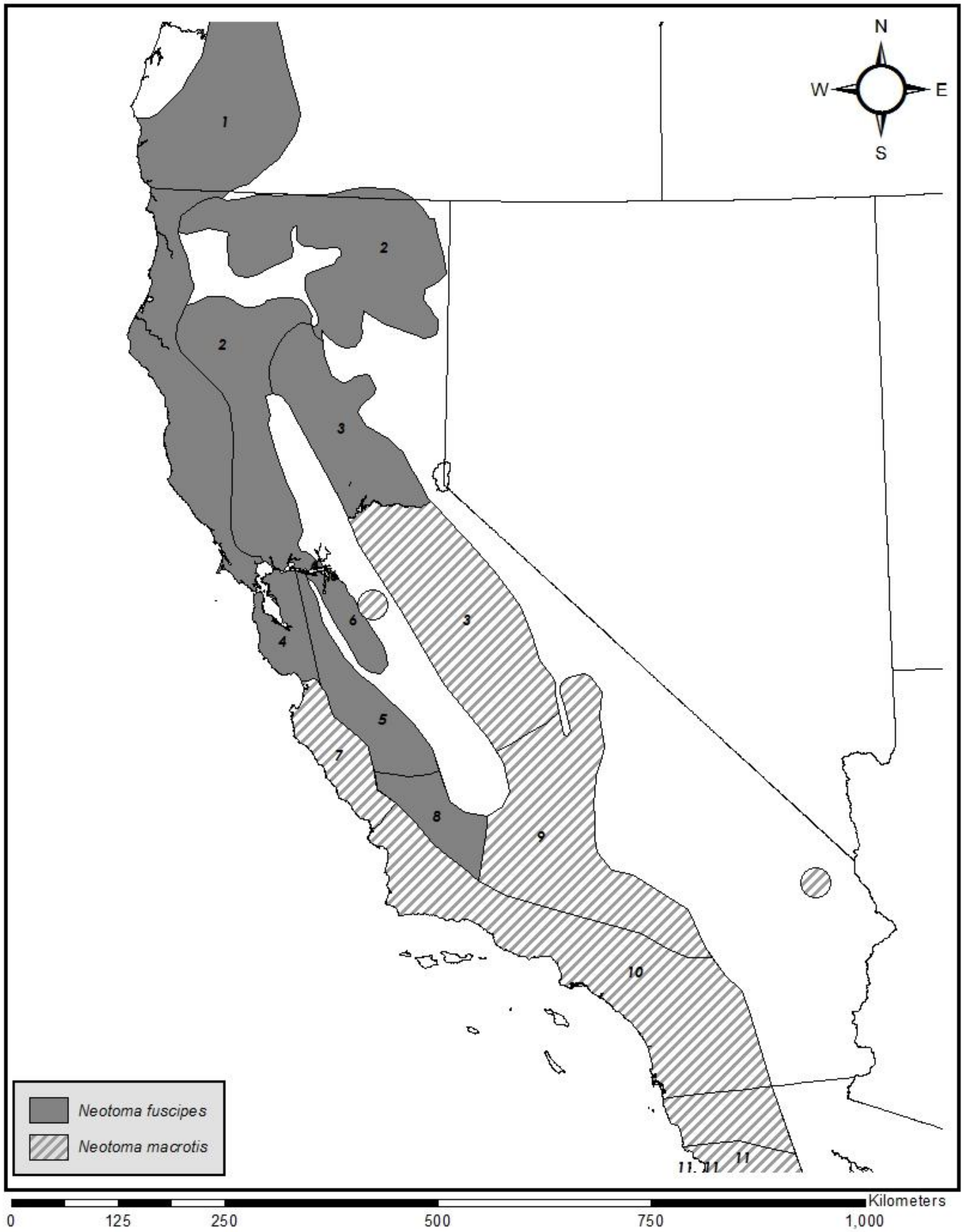

Figure 1. Range map of the *Neotoma fuscipes* and *Neotoma macrotis* subspecies distribution in North America. Subspecies distributions are indicated by numbers 1. *N. fuscipes monochroura* 2. *N. fuscipes fuscipes* 3. *N. fuscipes and N. macrotis streatori* 4. *N. fuscipes annectens* 5. *N. fuscipes perplexa* 6. *N. fuscipes riparia* 7. *N. macrotis luciana* 8. *N. fuscipes bullatior* 9. *N. macrotis simplex* 10. *N. macrotis macrotis* 11. *N. macrotis maritirensis*. Inset map illustrates the contact zone Along the Nacimiento River and the Salinas River. Range map modified from Matocq 2002a.

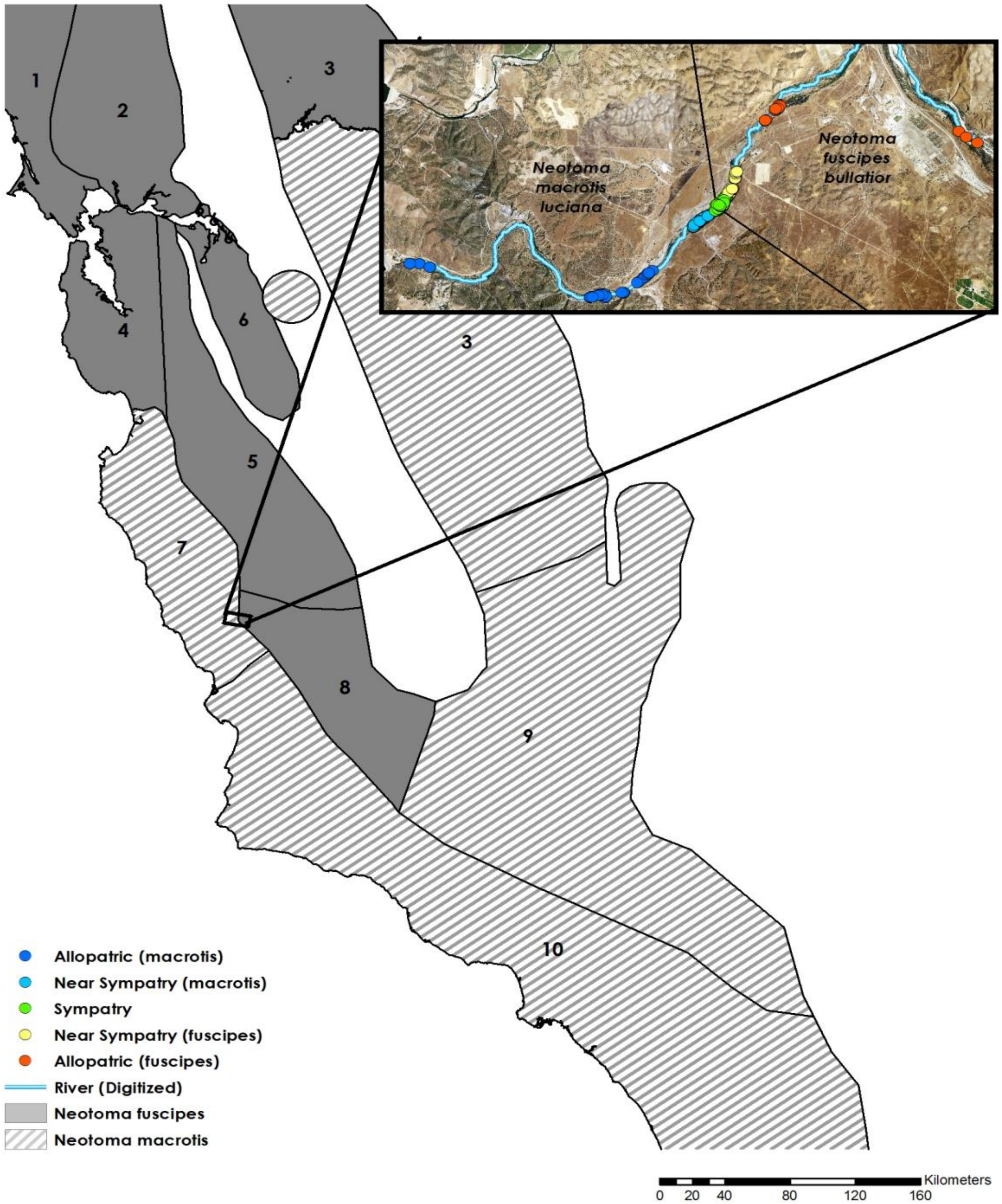

Figure 2. Range map of *Neotoma fuscipes* and *N. macrotis* in California. *Neotoma fuscipes* is shown in dark grey and *Neotoma macrotis* is shown in hatch markings. Zones along the riparian corridor are shown: allopatric *macrotis* in blue, near allopatric *macrotis* in light blue, sympatry in green, near allopatric *fuscipes* in yellow, and allopatric *fuscipes* in orange. Range map modified from Matocq 2002a.

In spite of genetic and morphological distinctions between these sister taxa, evidence suggests that these two sister species are capable of hybridizing. Hooper (1938) recognized that there was some degree of intergradation between the woodrats from the Monterey Bay and the Salinas Valley regions, where the south and inner Coast Ranges meet (Figure 1). Matocq (2002a) analyzed mitochondrial sequence variation of 47 individuals from this possible contact zone and identified three putative hybrids. Haynie et al. (2007) substantiated Matocq's (2002a, 2002b) findings that *N. fuscipes* and *N. macrotis* are distinct species, and that there is a contact zone with hybrids along the Nacimiento River corridor on the Camp Roberts Military Reservation (Figure 1). Most recently, Coyner et al. (2015) estimated the size of the contact zone, or zone of sympatry, by analyzing 15 nuclear microsatellite loci in 851 woodrats from the same animals used herein and employed a sliding window analysis to determine the size and location of the contact zone. The zone of secondary contact, the area where the ranges of the two congeners overlap, is estimated to be limited to an approximate 500-meter length of (~1,650 linear feet) riparian habitat associated with the Nacimiento River (Coyner et al. 2015).

The two subspecies of each taxon that meet one another are *N. fuscipes bullatior* and *N. macrotis luciana* (Figure 1). The Bullatior subspecies of the dusky-footed woodrat (*Neotoma fuscipes bullatior*) is found within the Salinas Valley south through interior San Luis Obispo County and into northeastern Santa Barbara County (Hall 1981 p. 682). The big-eared Monterey woodrat subspecies (*Neotoma macrotis luciana*) is found in the adjacent Santa Lucia coast range and east down the Lake Nacimiento and Nacimiento River drainage and south through Los Osos, California (Hall 1981 p. 682).

Coyner et al. (2015) suggest that *N. fuscipes* may have expanded its range west up the Nacimiento River drainage into the range of *N. macrotis*. Within this zone of sympatry, these lineages interact genetically as demonstrated by the presence of hybrid genotypes (Coyner et al. 2015, Haynie et al. 2007, Matocq 2002b).

The Nacimiento River riparian zone harbors the habitat that the woodrats occupy. This riparian habitat follows the river in a linear, east-to-west fashion and provides a natural transect for sampling. Importantly, the physical confines of the deep river banks keep dispersing individuals primarily within the confines of this relatively homogeneous habitat corridor, and make for a relatively linear system. This system is ideal because it sets the boundaries of a geographically and ecologically defined transect for examining gene flow and morphological change through the zone of secondary contact.

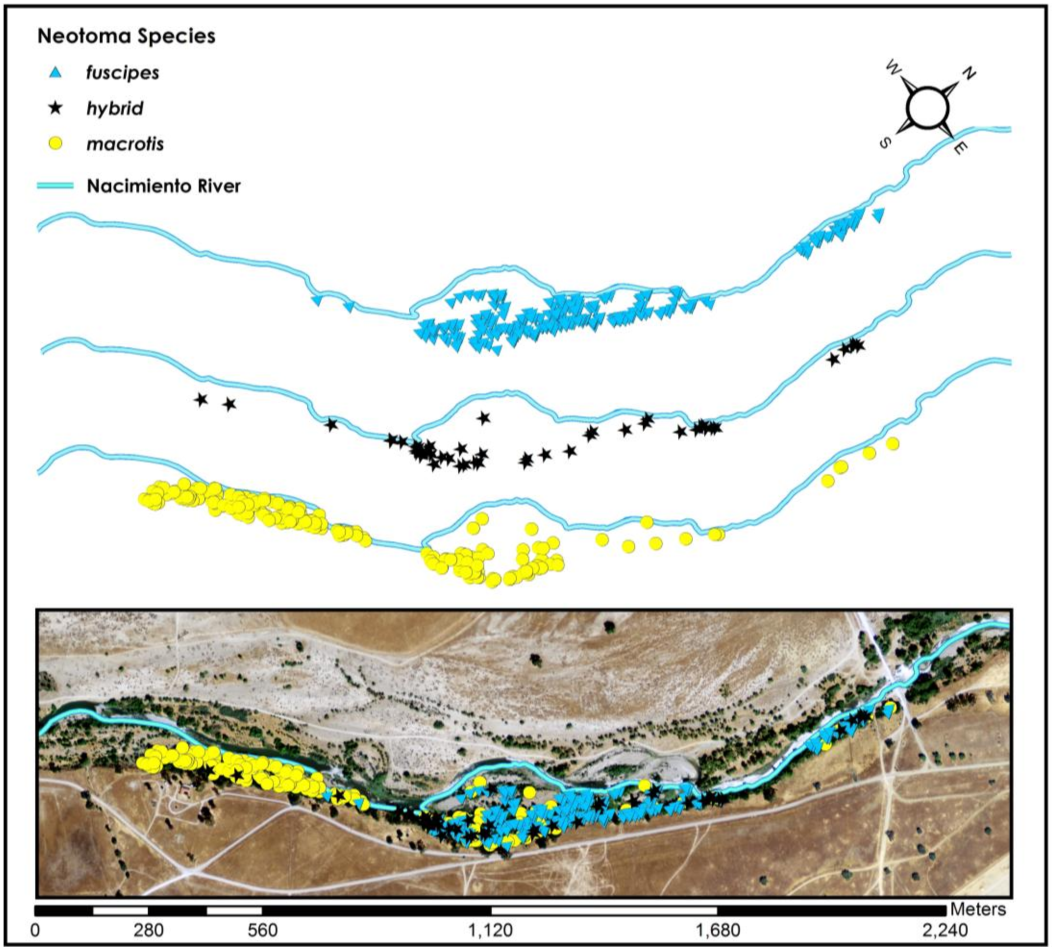

Figure 3. Aerial photograph of a ~2 km segment of riparian habitat occupied by woodrats along the Nacimiento River in California. Species distribution shown separately to demark areas of overlap more readily and are based on Coyner et al 2015.

Many factors play into the overall size and shape of a secondary contact zone. When hybrids are present, these contact zones are known as hybrid zones. Generally speaking, mammalian hybrid zones are narrow regions where genetically distinct populations meet, mate, and produce hybrids (Barton and Hewitt 1985). When sister species that have similar ecological requirements, or occupy similar ecological niches, meet in a secondary contact zone, a divergence in niche preference is predicted (Volpe and Rosenbaum 2000, p. 148). After an initial phase of competitive interaction between congeners occurs, each species is predicted to specialize, decreasing overlapping niche

breadth. After such specialization phenotypic differences between the two species are predicted to increase (Volpe and Rosenbaum 2000, p. 148). In the following paragraph I introduce evolutionary theory, and go into more detail later so that the specific application of the theory to this system will be more explicit and clear.

Competition is predicted to provide a selective force leading to morphological change. The type of competition driving morphological change may be examined by looking at the directionality of character displacement. When there are shifts in morphology that occur asymmetrically between body-size and shape, the relationship is referred to as being allometric. Size-independent allometric variation may be indicative of niche partitioning in closely related species, such as *N. macrotis* and *N. fuscipes* that utilize the same resources (Coyner et al. 2015). Matocq and Murphy (2007) suspected that competitive interactions may have resulted in character displacement (*i.e.*: changes in body-size and craniodental morphology), either providing a competitive advantage or reducing the effect of competition. Matocq and Murphy (2007) attributed craniodental displacement to independent evolutionary factors acting in each species, whereas they attributed convergence in body-size to both independent evolutionary factors and factors associated with shared inheritance in closely related sister taxa (Matocq and Murphy 2007). Although rooted in differing evolutionary processes, both morphological shifts are consistent with expectations of morphological change based on resource competition, whether direct or indirect (Matocq and Murphy 2007). The following sections are a literature review that further set the stage for speciation theory and how it relates to the results and conclusions with regard to character displacement associated with inter-specific competition.

Character Displacement

Niche Partitioning and Phenotypic Change under Minimal Introgression

Where the sister lineages of *N. macrotis* and *N. fuscipes* meet along the Nacimiento River there is no evidence of large-scale genetic introgression (Matocq 2002b; Coyner et al. 2015). Within the zone of sympatry the number of hybrids detected by using genetic analysis remains approximately 15 percent. The lack of wide-spread genetic introgression beyond the zones of sympatry suggests that ecological and evolutionary dynamics may be limiting genetic exchange through hybrid inferiority (Coyner et al. 2015). In all likelihood, a combination of pre-zygotic and post-zygotic isolating mechanisms helps maintain the narrow transition zone.

When two sister species that have similar ecological requirements expand their geographic ranges and meet in a common habitat, selection for divergent niche preference is expected. After an initial phase of competitive interaction that drives evolution, the sister taxa will then begin to exploit different ecological niches (Volpe and Rosenbaum 2000, p. 148). In sympatry, the two species will at first compete for suitable ecological niches in the common habitat. Eventually the two species will diverge behaviorally and over time may become morphologically different. Ultimately, each species will specialize. Individuals using overlapping niches will become fewer and differences between the two species will become more pronounced (Volpe and Rosenbaum 2000, p. 148). This selective process due to initial niche overlap will increase differentiation and eventually reduce competition (Volpe and Rosenbaum 2000, p. 148). In such cases, each population will adapt to its own distinct niche and will be able to coexist in sympatry, having diverged from a common or shared allopatric niche.

Allometry (Size-Dependent versus Size-Independent Character Shifts)

In morphometrics, allometry refers to the change in proportion of one character trait in relationship to an absolute scale (generally absolute size) as the organism changes (Gould 1966). In contrast, isometry is when the proportions of two traits remain the same, in relationship to absolute size variation. When morphological change differs asymmetrically in one trait versus another as a function of size, the relationship is referred to as allometric (Klingenberg 1996). Therefore, allometry is a change or modification of the proportions between characteristics. Body-size is regarded as a fairly plastic characteristic (Klingenberg 1996), while proportionality is not. More complex allometric variation may be produced by several biological phenomena, and three different levels of allometry are therefore distinguished (Gould 1966; Klingenberg 1996). The first level, static allometry, reflects individual variation within a population and *within* an age class. As such, it is a level of variation that is age (or size) independent, and reflects individual variation. The second level is known as ontogenetic allometry and is driven by growth processes, and therefore describes variation *between* age classes. As such, it is a level of variation that is age (or size) dependent. The third level is evolutionary allometry and is described by observable phylogenetic variation in shape or character trait scale among taxa (Klingenberg 1996; Gould 1966; Grant 1986; Cock 1966). As such, it is a level of variation that is age (and size) independent to the degree that the proportions among morphological traits have been re-patterned across the phylogeny and are independent of the body-size differences (isometric differences) between taxa. The re-patterning is more complex than the simple up or down regulation of a systemically acting growth hormone.

Hence I examine only adult woodrats to avoid confounding evolutionary and ontogenetic variation (Klingenberg 1996). If species or populations differ in character traits after variation-due-to-size has been removed from consideration, then I may confidently say that size-independent allometric shifts in one or more character traits have occurred (*i.e.*: evolutionary allometric shifts). These changes are in effect a change in the allometry or scale or proportionality between character traits. Deviations in the value of a population from a linear relationship between morphological structure and body-size of congeners suggest that an adaptive modification of structure independent of body-size (Grant 1986, p. 95) or isometric shift has occurred. This is because shifts in body-size, and in the size-dependent phenotypic traits, may occur entirely in response to ecological conditions. While re-patterning of the relationship between a phenotypic trait and body-size will require a genetic re-patterning of development. Such genetic traits are potentially species-specific and potentially heritable and thus subject to selection within a hybrid zone. Specifically, phenotypic changes in body-size inversely related to temperatures have been described in woodrats (*Neotoma*) (Cordero and Epps 2012, Ashton et al. 2000, Smith et al. 1995). Cordero and Epps found that in bushy-tailed woodrats (*Neotoma cinerea*) variation in body-size was predicted by temperature. However, skull-size compared to body-size displayed varying responses (Cordero and Epps 2012).

Deviations associated with allometry are interesting because they suggest that the possibility of adaptive modification of a character trait independent of other parts or traits (Grant 1986, p. 82). Shape may change regularly or irregularly. Irregular change is recognized by departures or deviations from a single line of allometry. Since much of the

variation between and within populations accompanies variation in body-size, the question arises how much shape variation is independent of size? Size-independent allometric variation may be indicative of niche partitioning in closely related species, such as *N. macrotis* and *N. fuscipes*, utilizing the same resources.

Contest Competition and Exploitative Competition

Classically, character displacement is a pattern wherein species differ more from one another in sympatry than in allopatry (Ridley 2004, p. 366). Character displacement may arise when two species have partly overlapping ranges: specifically, when they are allopatric in portions of their range and sympatric in other portions. When two closely related species overlap these species may be ecological competitors within the zone of contact or within sympatry. Differences may be accentuated in sympatry and weakened or lost entirely in those portions of their ranges that lie in allopatry (Brown and Wilson 1956). Variability in environmental factors across the transition zone and the history of isolation between sister taxa may influence the degree and pattern of observable shifts in character traits (Matocq and Murphy 2007; Pfennig and Martin 2010; Figure 5).

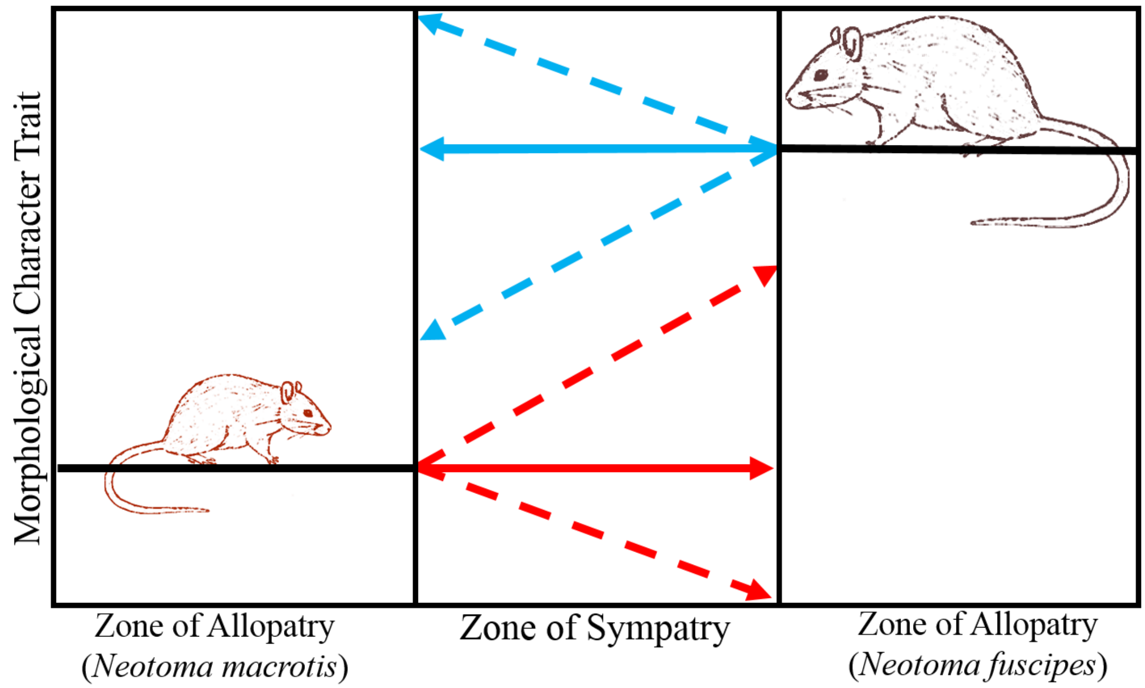

Figure 4. Possible character trait value shifts that may occur within the zone of sympatry (modified from Pfennig and Martin 2010). Illustrates character divergence or convergence that may occur in both species.

Ecological character displacement describes a pattern where morphological differences between sympatric species are enhanced through an adaptive response to inter-specific competition (Adams and Rohlf 2000). Competition forces each species to become more specialized. The standard interpretation of character displacement is that, in areas of allopatry, the present species is released from competition with the other species and evolves to exploit resources that would otherwise be exploited by its competitor. The allopatric population may evolve towards having a similar array of forms. In areas of sympatry, each species may evolve to exploit the resources that it is best adapted to (Ridley 2004, Chapter 13).

Lack (1947) was the first to introduce the method of comparing conspecific populations that are in sympatry with a heterospecific competitor, as opposed to those

that are in allopatry and thus not in the presence of the heterospecific competitor (pp. 125-130). Competitive interactions include indirect forms such as exploitative competition and direct forms such as contest competition, or interference competition. Exploitative competition is indirect because a shared resource becomes depleted asynchronously by the two species (Pianka 2011 p. 229; Amarasekare 2010). Contest competition arises when species compete directly with one another for resources (Pianka 2011 p 229; Amarasekare 2010). Hence depletion of shared resources by closely related and morphologically similar species will favor phenotypes exploiting new under-exploited resources, leading to diversifying selection for phenotypic divergence in one or both species (Adams and Rohlf 2000). This sympatric differentiation presumably occurs as a result of higher fitness in any individuals that experience reduced competition, thereby allowing the species to co-exist (Schluter 2000; Amarasekare 2010).

Convergence versus Divergence

A large body of literature examines divergence between sympatric populations, even though parallel and convergent displacements are theoretically possible (Schluter 2000). A history of exploitative competition is typically inferred from patterns of increased phenotypic differentiation in areas of sympatry relative to those seen in allopatry (Adams and Rohlf 2000; Pfennig and Murphy 2000; 2003). Contrary to the common pattern of character divergence in areas with sympatric sister taxa, Matocq and Murphy (2007) found character trait (body-size) convergence in woodrats along a putative contact zone in the western Sierra Nevada. They found that even without observable genetic exchange, the sister lineages may be affected by common ecological interactions that promote convergence and divergence in character traits in one or both

lineages (Matocq and Murphy 2007). In contrast to expectations of character displacement with exploitative competition, contest competition may lead to increases in body-size and therefore a convergence in body-size between two competing species (Abrams and Matsuda 1994; Van Valkenburgh and Wayne 1994) such as that seen by Matocq and Murphy (2007). Convergence in body-size will be beneficial when the outcome of contests is influenced by body-size. Species that overlap in terms of utilizing resources could change in a manner consistent with either exploitative or contest competition, or in a manner that is consistent with both (Van Valkenburgh and Wayne 1994; Matocq and Murphy 2007).

Furthermore, across the zone of parapatry or putative historical contact zone in the Sierra Nevada, Matocq and Murphy (2007) found that *N. fuscipes* and *N. macrotis* showed little to no evidence of recent genetic exchange. This is very likely a result of the American River forming a geographical barrier between the two ranges, resulting in no true zone of sympatry. Overall, they found greater inter-specific divergence in craniodental morphology near the putative contact zone than between allopatric populations (Matocq and Murphy 2007). Functional correlations between fine-scale differences in diet composition and the craniodental measurements taken from the Sierra Nevada study are not fully understood. However, differences in craniodental characters, such as length of the rostrum, may be associated with major dietary differences (Satoh 1997 as cited in Matocq and Murphy 2007). For *N. fuscipes* in particular, populations changed significantly as they neared the American River and the zone of parapatry. Moreover, displacement was matched by an increase in body-size within species and convergence in body-size between species near the area of possible historical contact.

Matocq and Murphy (2007) suggest that the observable morphological changes between *N. fuscipes* and *N. macrotis* may be associated with ecological interactions between the two species that occurred at some point in the past (Matocq and Murphy 2007). It is possible that the morphological displacement observed in the Sierra Nevadan woodrats may be associated with natural variation in environment factors across the putative contact zone and zones of allopatry.

Environmental Gradients, Clines, and Convergence

A cline is a gradient of continuous variation in a phenotypic or genetic character trait within a species. For a number of reasons clines may arise independently of contact zones. Natural selection may favor a slightly different body-size along a geographical gradient. For example, Bergmann's Rule, a fundamental principle in biogeography, asserts that body-size varies with changes of latitude (Ashton et al. 2000, Smith et al. 1995). Alternatively, the environment may change discontinuously in space, and different genes may be adapted to two different regions. A cline may then arise because of gene flow or movements of individuals across the boundary between the regions (Ridley 2004, p. 362).

Clines may be smooth or "stepped", depending on how suddenly gene frequencies and selection change in space. If the environment (selection) varies smoothly, then the cline in heritable traits will also be smooth. A similar pattern may be seen in environmentally influenced phenotypically plastic traits not responding to selection but responding to environmental gradients. Instead if the environment changes more suddenly, the cline in heritable traits may be more stepped. The shape of the step depends on the fitness difference between the genotypes in the two regions, the fitness of

any intermediate genotypes (such as heterozygotes or recombinants), and the amount of gene flow. However, a sudden change in environment or the presence of an ecotone is not the only explanation for stepped clines. Stepped clines may also result when the ranges of two formerly separate populations expand and the two populations meet, forming a secondary contact zone with some introgression smoothing the otherwise stepped cline (Ridley 2004, p. 363).

Natural clines in environmental factors such as temperature, habitat type, and habitat structure, may be clearly seen in clines observed within phenotypic character traits. This may be specifically observed in cases where body-size converges along a transect. Convergence is not an uncommon phenomenon in nature. Many unrelated or remotely related organisms have converged in appearance as a consequence of exploitation of similar ecological niches (Volpe and Rosenbaum 2000, p. 205). Matocq and Murphy (2007) suggest that independent evolution within populations has contributed significantly to the observed craniodental displacement.

According to Barton and Hewitt (1985), models of clines in continuous habitats fall into two classes (Murray 1977, Chapter 5). In the first class, dispersal is negligible. Selection maintains a stable equilibrium at each locality (Barton and Hewitt 1985). This type is a dispersal-independent cline. In the second class, the homogenizing effect of dispersal may be balanced or counteracted by a heterogeneous or patchy environment. This includes neutral clines, in which an initially steep gradient decays with time and dispersal-selection balance, in which either difference in environment (Haldane 1948) or in selection against intermediate genotypes (Barton and Hewitt 1985) maintains a stable cline. This last cline is often referred to as a tension zone. The width of the hybrid zone

will be dependent on dispersal distance and the occurrence of interbreeding, or a combination of the two. Also, the presence of a homogeneous or heterogeneous environment plays a role in the width of a contact zone.

Ways to account for phenotypic variation attributable to clinal, or heterogeneous, environmental variation were explored. By excluding hybrid woodrats from the analysis species-specific variation in character traits was accounted for. Threfore, elucidating the species level effects associated with heightened competition. Furthermore, by examining the nature of the phenotypic change the types of competitive pressure that are being introduced into the system within the zone of sympatry were infered.

HYPOTHESES AND PREDICTIONS

This research seeks to deteremine whether distinctive character shifts in sympatric populations occur, by focusing not on direct estimators of competition but rather on indirect measures of morphological character trait divergence or convergence as proxies for competition. When *N. fuscipes* and *N. macrotis* distributions overlap, I test morphological traits of these species for evidence that they compete for resources both indirectly, through exploitative competition, or directly, through contest competition, or through a combination of these processes. Whether morphological variation in body-size and size-independent character traits differ from what is predicted due to isometry. Then if character traits differ from isometry, I test to what extent they do so. Furthermore, whether character displacement does indeed occur and seek to determine whether this variation is consistent with what is predicted due to contest competition, exploitative competition, or a combination of these processes was examined. Additionally, by accounting for phenotypic variation above and beyond what is explained by sympatry or allopatry my statistical models quantify phenotypic variation associated with variation in natural environmental factors.

Diagnostic Characteristics Hypothesis

Allopatric populations of sister taxa *N. fuscipes* and *N. macrotis* will exhibit species-specific homogeneous and diagnostic suites of morphological traits that may be quantified through examination of live animals.

Diagnostic Characteristics Predictions

I predict that in the allopatric populations of *N. fuscipes* and *N. macrotis* I will observe distinct differences in adult male phallus morphology. I predict that these differences in phallus morphology will provide a reliable means of morphologically diagnosing these species. Additionally, I predict that patterns of variation in external morphological character traits will be distinctive and unique in each species. I predict that I may use these distinct differences in external morphology (in live animals) to further differentiate the sister taxa into morphospecies.

Convergence and Divergence via Allometric Re-patterning Hypothesis

In the contact zone where *N. fuscipes* and *N. macrotis* distributions overlap, competition will be heightened resulting in allometric character traits shifts.

Convergence and Divergence via Allometric Re-patterning Predictions

According to the results of Matocq and Murphy (2007), sympatric populations will exhibit a distinct quantifiable, size-dependent morphological character shift relative to the allopatric populations. Specifically, in comparing allopatric populations to sympatric populations I predict a body-size (represented by body weight) convergence in the area of sympatry. When comparing allopatric populations to sympatric populations, I predict I will discover a detectable re-patterning of allometric relationships among external character traits.

A Narrow, Dispersal-Independent Clinal Pattern Hypothesis

Within the zone of sympatry, where *N. fuscipes* and *N. macrotis* distributions overlap, the differentiation in morphological characteristics between the two sister taxa will exhibit a narrow, dispersal-independent cline between zones of sympatry and near sympatry in contrast to zones of allopatry. I make the assumptions of a density-independent cline, with overall negligible dispersal of offspring, and of a secondary contact zone in an equilibrium state.

A Narrow, Dispersal-Independent Clinal Pattern Predictions

Across all zones of the transect, I will observe a quantifiable, narrow cline in morphological character traits. Additionally, I predict that a gradient in size-independent character displacement will be observed between zones of sympatry and near sympatry in contrast to zones of allopatry.

MATERIALS AND METHODS

Study Area

The study area was located south of the Salinas Valley on the border of northern San Luis Obispo County and southern Monterey County, in central coastal California (Figure 1). The study area included an approximately 20-kilometer transect along the southern banks of the Nacimiento River and parts of the Salinas River on and adjacent to Camp Roberts Military Reservation (Figure 1). In general, woodrats of both species were restricted to the band of riparian habitat. Therefore, I focused this study along a relatively linear transect in order to locate the secondary contact zone and to characterize both species, morphologically and genetically, in sympatry and in allopatry. Previous work in the region (Hopper 1938 and Matocq 2002a) and relevant museum records, were used to delimit a study area. These data were used to help locate the hypothesized zone of sympatry between the sister taxa. In this area, the adult males of the two sister species could generally be distinguished by body-size and pelage coloration, and by examination of the external genitalia, specifically the glans penis (Matocq 2002a and Coyner et al. 2015). The approximately 20-kilometer transect was designed to include the secondary contact zone or zone of sympatry, as well as near sympatric and allopatric individuals of *N. fuscipes bullatior* to the east and *N. macrotis luciana* to the west (Coyner et al. 2015). The general location, size, and extent of the contact zone was initially delimited by examining the phallus of captured adult male woodrats.

Sampling Methodology

Woodrat Captures and Georeferencing

Woodrats of *N. fuscipes*, *N. macrotis* and hybrid origin, were captured, sampled (see below) and then released at the site of capture. Within the riparian corridor transect, Tom-A-Hawk 6” x 12” and Sherman XLK live traps were placed in pairs adjacent to existing woodrat middens. Data points were collected and post processed for each associated midden (N=686) using a Trimble™ hand-held unit with submeter accuracy. The traps were left in the same location or station for at least three consecutive nights. Traps were baited with a mixture of peanut butter and rolled oats and were set at sunset. Traps were checked starting at 11 pm to minimize potential negative impacts to breeding woodrats. Trapping and handling protocols were established in conformity with the American Society of Mammalogists (Sikes et al. 2011), under protocols approved by the Institutional Animal Care and Use Committee of the University of Nevada Reno (IACUC #00350) and a scientific collecting permit issued to Matocq by the California Department of Fish and Wildlife (SC-001743).

Mensural Characters and Tissue Collection

Upon first capture, animals were marked with uniquely numbered stainless steel ear tags (Monel 1005-1, National Band and Tag Co.), then sexed and aged. In addition, a small piece of tissue was biopsied from the left ear with sterile surgical scissors and stored in 95% ethanol. Measurements of morphological character traits were recorded for each live-captured individual. The recorded morphological character traits included weight in grams, length of ear from notch (mm), length of hind foot (mm), breadth

(width) of rostrum (mm), and length of tail (mm). Additionally, woodrat age, sex, and reproductive status were recorded.

Sampling Locations along a Transect

Representative allopatric populations for each species were selected approximately 10 kilometers upstream and 10 kilometers downstream from the putative contact zone. These sites were selected based on habitat suitability on public lands. Representative allopatric populations for each species *N. macrotis* and *N. fuscipes* were likewise sampled. The allopatric population of *N. macrotis* (allopatric *macrotis* herein) was sampled just below the Nacimiento Dam and the allopatric population for *N. fuscipes* (allopatric *fuscipes* herein) was sampled at the southern unit of Big Sandy Wildlife Area within the Salinas River corridor (Figure 2). Samples of each species were also taken near but outside of the area of true sympatry and are referred to as "near sympatry *macrotis*" and "near sympatry *fuscipes*". The zone of sympatry was exhaustively sampled from April through September 2010, and thus my sample includes nearly all woodrats on the site at the time of the study (Coyner et al. 2015; Figure 4).

Genetic Analysis

Between April and September 2010, 1,202 individual woodrats were captured and sampled along the transect (Figures 1 and 4). Since non-adult male woodrats, including hybrids of all age classes, could not be confidently identified in the field, measurements of morphological character traits were recorded. Genetic samples were sent to Matocq's lab at the Nevada Genomics Center, University of Nevada at Reno. Whole genomic DNA was isolated using the DNeasy Tissue Kit (Qiagen, Valencia, California). Fifteen

microsatellite loci were analyzed for 851 of the 1,202 individuals captured during 2010. Refer to Coyner et al. (2015) for details on methodology used to analyze the genetic samples collected for this study. For the purpose of this study, I only examine non-hybrid adult individuals (N=607).

Analytical Methodology

Assessing Distance Across the Transect

Along the transect, the mean central point of all midden GPS locations was determined in ArcGIS™ 10.2, using the Central Feature tool in the Spatial Statistic toolkit. This central feature represented the center point of the contact zone or zone of sympatry. The center point was determined by averaging all of the locations across the transect using the Near tool in the Analysis Toolkit. Then the Euclidian distance or linear distance (in meters) of the GPS coordinates for each captured woodrat was calculated. The central point was denoted as point zero. Individual capture locations upriver and to the west of the central point were denoted as negative distances. Individual capture locations downriver and to the east of the central point were denoted as positive distances. This measurement of distance represents the Euclidean linear variable.

Morphological Characters – Transformation and Imputation

For each woodrat, body-size was represented by weight in grams and $\log_{10}$-transformed, while length of ear from notch, breadth of rostrum, hind foot length, and tail length were measured and represented by millimeters. Exploratory data analysis was run on all adult woodrats across the entire transect using JMP® Pro 11.2. Weight values from

pregnant females (N = 27) and tail length from individuals with incomplete tails (N = 63) (where a portion of the tail was missing) were imputed.

Hypothesis Testing – The Two-Model Approach

With the goal of testing my hypotheses and predictions regarding character displacement while accounting for phenotypic variation associated with environmental effects, I built two statistical models. The first model (Species-Sex-Zone General Linear Model [SSZ Model herein]) was a general linear model (GLM) that took into account variation associated with the categorical data of species (*N. macrotis* and *N. fuscipes*), sex (male and female), and zone (sympatry, near sympatry, and allopatry). Additionally, the species-by-zone interaction was included (species*zone) as well as the sex-by-species interaction (sex*species). The second model (Species-Sex-Zone-Distance General Linear Model [SSZD Model herein]) extended SSZ Model by adding a continuous distance variable, distance in meters from the central feature. Since to some extent, species is confounded with distance, the inclusion of the distance term in the second set of models allows me to examine species differences adjusted for possible cline effects within species and associated with naturally occurring environmental factors. The first model assumes a homogeneous environment across all zones or along the transect. The two models are depicted below:

SSZ Model: y* = species + sex + zone + species*sex +species*zone

SSZD Model: y* = species + sex + zone + species*sex +species*zone + distance

** y represents a morphological character traits*

To limit exposure to Type I error, before I ran the GLM models, multivariate versions of both models were first fit using multiple analysis of variance (MANOVA) in JMP® Pro 11.2 (SAS Institute) with the five morphological character traits as the response variables. For the MANOVA analysis, the five morphological character traits were standardized ([individual mean – overall mean]/overall standard deviation). The Wilks' lambda test was used to assess the interaction between species and zone. If the interaction term was found to be statistically significant, subsequent univariate models were used to further examine the pattern of variation for individual character traits. By limiting the number of univariate tests, the exposure to Type I error risk was also limited.

Diagnostic Characteristics

To test whether a distinct difference in observable adult male phallus morphology between the two species along the Nacimiento River drainage might be used as a reliable means of determining species I compared observed phallus morphology with expected genotype using Fisher's Exact Test in JMP® Pro 11.2. I tested whether allopatric populations of sister taxa *N. fuscipes* and *N. macrotis* would exhibit species-specific homogeneous suites of character traits that might be quantified through examination of morphological character traits. I used the standard least squares personality within the Fit Model platform in JMP® Pro 11.2 to test the SSZ Model and SSZD Model. More specifically, I focused on the species-by-zone interaction by examining contrasts between the two zones of allopatry. On the species-by-zone interaction I examined contrasts by species between the two zones of allopatry. For the SSZ Model and SSZD Model, I recorded p-values for the least squares mean on each of the five character traits.

Quantitative comparisons were made of the results from the two models, SSZ Model and SSZD Model.

Convergence and Divergence via Allometric Re-patterning

To test whether a detectable re-patterning of allometric character traits occurred as sampling approached the contact zone, I used the standard least squares personality within the Fit Model platform `in JMP® Pro 11.2 to test the SSZ Model and SSZD Model. On the species-by-zone interaction I examined contrasts by species between the zone of allopatry and the zone of sympatry. For the SSZ Model and SSZD Model, I recorded p-values for the least squares mean on each of the five character traits. Quantitative comparisons of the results from the two models were made, SSZ Model and SSZD Model.

A Narrow, Dispersal-Independent Clinal Pattern

To test if the differentiation in morphological characteristics between the two sister taxa would exhibit a narrow dispersal-independent cline to the east and west of the center point of the putative contact zone I used the standard least squares personality within the Fit Model platform in JMP® Pro 11.2 to test SSZ Model and SSZD Model. On the species-by-zone interaction I examined contrasts by species between zones of sympatry, in comparison to zones of allopatry, and including data from near sympatry. For the SSZ Model and SSZD Model, I recorded p-values for the least squares mean on each of the five character traits. Quantitative comparisons were made of the results from the two models, SSZ Model and SSZD Model.

RESULTS

Field Sampling and Genetic Results

I captured and sampled a total of 1,202 unique woodrats. Of the 1,202 woodrats captured 667 were adults, 167 were subadults, and 368 were juveniles. For the purposes of this study, morphological characteristics were only analyzed for adult male and female woodrats. Genotype data from the University of Nevada Reno were used to determine the species for the woodrats captured. Hybrids, as defined in Coyner et al. 2015, were also identified using these data and excluded from further analysis. Refer to Table 1 below for a summary of sample size of adult woodrats across zones by species, sex, and hybrid status.

TABLE 1. SAMPLE SIZE OF ADULT WOODRATS ACROSS ZONES BY SPECIES AND SEX

	Allopatric (*macrotis*)	Near Sympatry (*macrotis*)	Sympatry	Near Sympatry (*fuscipes*)	Allopatric (*fuscipes*)	Total Adults
ADULT FEMALE	41	70	122	61	28	322
Neotoma macrotis	41	67	31	6	0	145
hybrid	0	2	11	7	2	22
Neotoma fuscipes	0	1	80	48	26	155
ADULT MALE	53	82	112	54	30	331
Neotoma macrotis	53	79	35	4	0	171
hybrid	0	2	12	8	2	24
Neotoma fuscipes	0	1	65	42	28	136
TOTAL ADULTS	94	152	234	115	58	653

The Two-Mode Appoach

The MANOVA of the SSZ Model (Species-Sex-Zone General Linear Model) and the SSZD Model (Species-Sex-Zone-Distance General Linear Model). A statistically significant difference for the species-by-zone interaction was detected in the SSZ Model

(Wilks' lambda statistic = 0.9461554, approximate, F= 3.3392, p = 0.0002; df = 10) and in the SSZD Model (Wilks' lambda statistic = 0.9311072, approximate F= 4.3166, p < 0.0001; df = 10). Refer to Table 2 below for a summary of all test statistics discussed.

TABLE 2. MANOVA TEST STATISTICS FOR THE SPECIES-BY-ZONE INTERACTION WITH A COMPARISON OF MODELS

Model	Character Trait	DF	SS	F Ratio	Prob > F
SSZ	Weight Log10	2	0.02771461	3.905	0.0207
SSZD	Weight Log10	2	0.02993	4.3578	0.0132
SSZ	Ear (mm)	2	49.21261078	5.0937	0.0064
SSZD	Ear (mm)	2	72.87154	7.6188	0.0005
SSZ	Rostrum (mm)	2	5.51151819	5.0091	0.0071
SSZD	Rostrum (mm)	2	3.46033	3.1488	0.044
SSZ	Hind Foot (mm)	2	22.52085527	2.4882	0.084
SSZD	Hind Foot (mm)	2	13.26585	1.4642	0.2322
SSZ	Tail (mm)	2	735.0601709	2.4872	0.0841
SSZD	Tail (mm)	2	1107.98533	3.8271	0.0223

Characterizing Morphology

Diagnostic Characteristics

From the results of a Fisher's exact test, phallus morphology was determined to be a statistically reliable means of determining species in adult male woodrats (p < 0.0001, N = 331). The p-values for the least squares mean on each of the five character traits are based on the species-by-zone interaction contrasts between the two zones of allopatry (*N. macrotis* allopatry versus *N. fuscipes* allopatry).

The allopatric populations of sister taxa *N. fuscipes* and *N. macrotis* exhibited statistically significant species-specific homogeneous suites of character traits. Based on the results of the SSZ Model, *N. fuscipes* was statistically significantly larger than *N. macrotis* with regard to body-size (weight) (SSZ Model: p < 0.0001), length of ear (SSZ

Model: p < 0.0001), breadth of rostrum (SSZ Model: p = 0.0167), length of hind foot (SSZ Model: p < 0.0001), and length of tail (SSZ Model: p < 0.0001). Therefore, in areas of allopatry, the sister species are distinct and diagnosable in all five measured character traits.

When accounting for clinal variation within the system there was no statistically significant difference between the species with regard to body-size (SSZD Model: p = 0.3638), breadth of rostrum (SSZD Model: p =0.6943) and the length of tail (SSZD Model: p = 0.3551). However, based on the results of the SSZD Model *N. fuscipes* statistically significantly larger than *N. macrotis* with regard to length of ear (SSZD Model: p < 0.0001) and length of hind foot (SSZD Model: p = 0.0024). Refer to table Table 3 below for a summary of all test statistics for contrasts between zones of allopatry by species for the species-by-zone interaction. For graphical representation, compare zones of allopatry for each species between SSZ Model and SSZD Model in Figures 5 through 9.

TABLE 3. CONTRASTING ZONES OF ALLOPATRY BY SPECIES FOR THE SPECIES-BY-ZONE INTERACTION WITH A COMPARISON OF MODELS

Model	Character Trait	SS	DenDF	F Ratio	Prob > F
SSZ	Weight Log10 (g)	0.294714804	580	83.05	<0.0001
SSZD	Weight Log10 (g)	0.002836978	579	0.826	0.3638
SSZ	Ear (mm)	316.7379908	556	65.5678	<0.0001
SSZD	Ear (mm)	131.9772893	555	27.5969	<0.0001
SSZ	Rostrum (mm)	3.176080095	407	5.7732	0.0167
SSZD	Rostrum (mm)	0.085024276	406	0.1547	0.6943
SSZ	Hind Foot (mm)	221.2704043	556	48.8936	<0.0001
SSZD	Hind Foot (mm)	42.23743664	555	9.3236	0.0024
SSZ	Tail (mm)	6852.403481	562	46.3719	<0.0001
SSZD	Tail (mm)	123.9744388	561	0.8565	0.3551

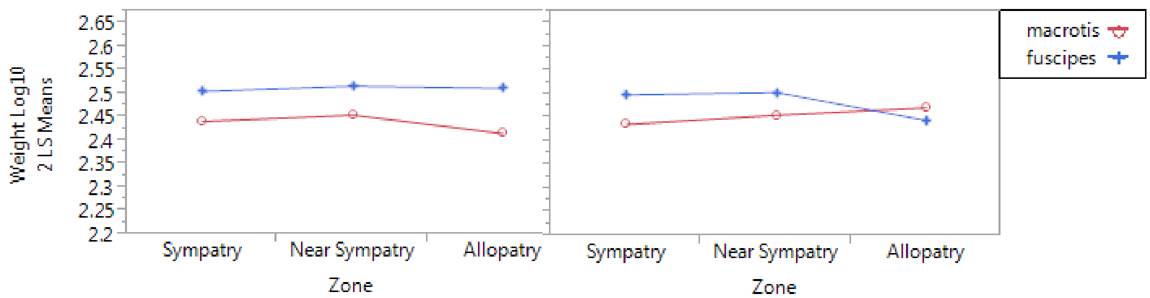

Figure 5. Least means square plot of body-size or weight log10 (grams) by species, *Neotoma macrotis* in blue and *N. fuscipes* in red (N=587). A side by side comparison of SSZ Model (p = 0.0207) on the left versus the SSZD Model (p = 0.0132) on the right.

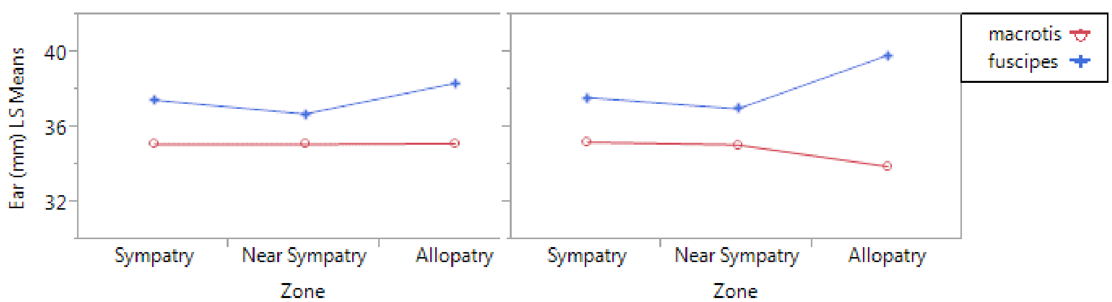

Figure 6. Least squares mean plot of length of ear (mm) by species, *Neotoma macrotis* in blue and *N. fuscipes* in red (N=563). A side by side comparison of SSZ Model (p = 0.0064) on the left versus the SSZD Model (p = 0.0005) on the right.

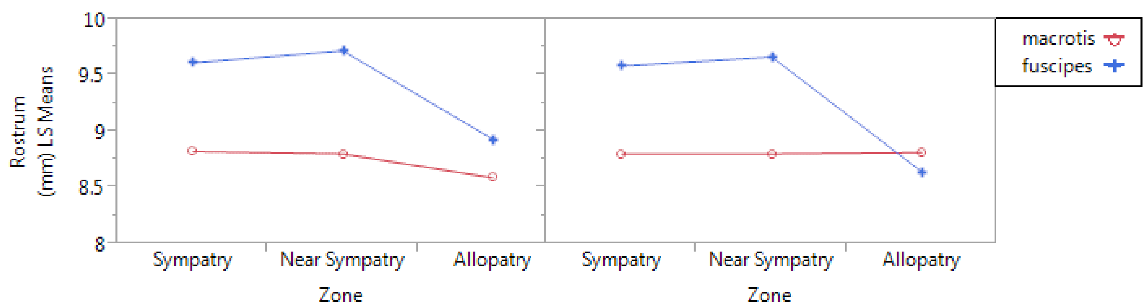

Figure 7. Least squares mean plot of breadth of rostrum (mm) by species, *Neotoma macrotis* in blue and *N. fuscipes* in red (N=414). A side by side comparison of SSZ Model (p = 0.0071) on the left versus the SSZD Model (p = 0.0440) on the right.

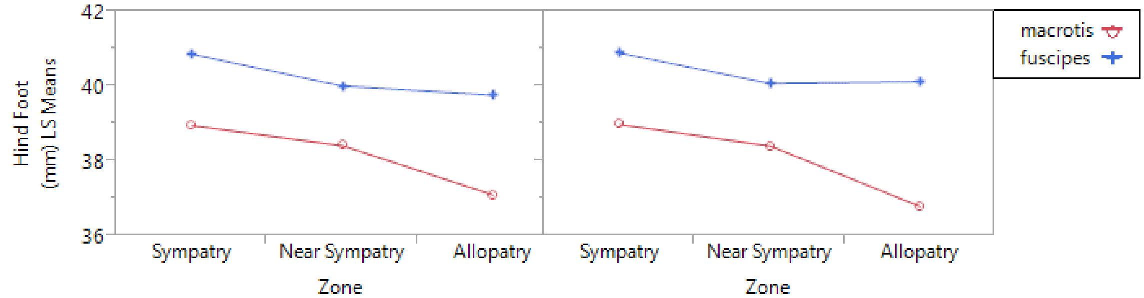

Figure 8. Least squares mean plot of length of hind foot (mm) by species, *Neotoma macrotis* in blue and *N. fuscipes* in red (N=563). A side by side comparison of SSZ Model (p = 0.0840) on the left versus the SSZD Model (p = 0.2322) on the right.

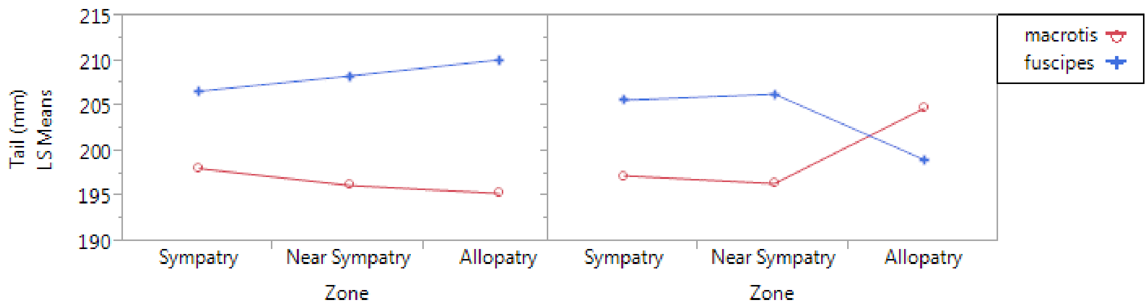

Figure 9. Least squares mean plot of length of tail (mm) by species. *Neotoma macrotis* in blue and *N. fuscipes* in red (N=569). A side by side comparison of SSZ Model (p = 0.0841) on the left versus the SSZD Model (p = 0.0223) on the right.

Convergence and Divergence via Allometric Re-patterning

The p-values for the least squares mean on each of the five character traits are based on the species-by-zone interaction contrasts between the zone of sympatry and zones of allopatry (sympatry versus allopatry). I compared these p-values with the slope for each character trait to determine if convergence or divergence was occurring at a significant level between zones of allopatry to the zone of sympatry. Additionally, the slopes and direction of the character displacement were examined to determine if evidence of re-patterning was present.

Based on ther results of both models, neither species exhibited a statististically significant convergence or divergence with regard to length of tail (SSZ Model: $p = 0.0901$; SSZD Model: $p = 0.0846$) from expectations of isometry between zones of sympatry and allopatry. Based on the results of the SSZ Model, *N. macrotis* exhibited a statistically significant convergence towards *N. fuscipes* with regard to body-size (SSZ Model: $p = 0.0240$) between zones of sympatry and allopatry. However, based on the results of the SSZD Model, both species exhibited a statistically significant divergence with regard to body-size or weight (SSZD Model: $p = 0.0054$) between zones of sympatry and allopatry. Based on the results of both models, *N. macrotis* exhibited a statistically significant convergence towards *N. fuscipes* with regard to length of hind foot (SSZ Model: $p = <0.0001$; SSZD Model: $p < 0.0001$) between zones of sympatry and allopatry.

Based on the results of the SSZ Model, neither species exhibited a statistically significant convergence or divergence with regard to length of ear (SSZ Model: $p = 0.0561$) from expectations of isometry between zones of sympatry and allopatry. However, based on the results of the SSZD Model *N. macrotis* exhibited a statistically significant convergence towards *N. fuscipes* with regard to length of ear (SSZ Model: $p = 0.0022$) between zones of sympatry and allopatry. Based on the results of both models, *N. fuscipes* exhibited a statistically significant divergence from *N. macrotis* with regard to breadth of rostrum (SSZ Model: $p < 0.0001$; SSZD Model: $p < 0.0001$) between zones of sympatry and allopatry.

The results of convergence in body-size, length of ear, and length of hind foot and the divergence in breadth of rostrum were more statistically significant in the second

model (SSZD Model) than in the first model (SSZ Model). Refer to table Table 4 below for a summary of all test statistics for contrasting zones sympatry and allopatry by species for the species-by-zone interaction. For graphical representation, compare zones of sympatry and zones of allopatry between SSZ Model and SSZD Model in Figures 5 through 9.

TABLE 4. CONTRASTING ZONES OF SYMPATRY AND ZONES OF ALLOPATRY BY SPECIES FOR THE SPECIES-BY-ZONE INTERACTION WITH A COMPARISON OF MODELS					
Model	Character Trait	SS	DenDF	F Ratio	Prob > F
SSZ	Weight Log10 (g)	0.026650829	580	3.7551	0.0240
SSZD	Weight Log10 (g)	0.036176716	579	5.2665	0.0054
SSZ	Ear (mm)	27.96721741	556	2.8947	0.0561
SSZD	Ear (mm)	59.18623404	555	6.188	0.0022
SSZ	Rostrum (mm)	14.37117674	407	13.0613	<0.0001
SSZD	Rostrum (mm)	13.87242134	406	12.6236	<0.0001
SSZ	Hind Foot (mm)	168.587573	556	18.6262	<0.0001
SSZD	Hind Foot (mm)	163.7345917	555	18.0715	<0.0001
SSZ	Tail (mm)	714.3912144	562	2.4172	0.0901
SSZD	Tail (mm)	718.2202424	561	2.4808	0.0846

A Narrow, Dispersal-Independent Clinal Pattern

The p-values for the least squares mean on each of the five character traits are based on the species-by-zone interaction contrasts between the zones of sympatry and near sympatry, as compared to zones of allopatry (sympatry versus near sympatry, compared to allopatry). I compared these p-values with the slope for each character trait to determine if convergence or divergence was occurring at a significant level or not across zones of sympatry and near sympatry in comparison to zones of allopatry.

Based on the results of the SSZ Model length of tail (SSZ Model: $p = 0.2053$) did not exhibit a statistical convergence or divergence from expectations of isometry in either species between zones of sympatry and near sympatry in comparison to zones of

allopatry. However, based on the results of the SSZD Model length of tail (SSZD Model: $p = 0.0391$) exhibited a statistically statistical divergence between the two species from between zones of sympatry and near sympatry in comparison to zones of allopatry. Based on the results of the SSZ Model, *N. macrotis* exhibited a statistically significant convergence towards *N. fuscipes* with regard to body-size (SSZ Model: $p < 0.0001$) between zones of sympatry and near sympatry in comparison to zones of allopatry. However, based on the results of the SSZD Model, *N. macrotis* exhibited a statistically significant divergence from *N. fuscipes* with regard to body-size (SSZD Model: $p = 0.0010$) between zones of sympatry and near sympatry in comparison to zones of allopatry. Based on the results of both models, *N. macrotis* exhibited a statistically significant convergence towards *N. fuscipes* with regard to length of ear (SSZ Model: $p < 0.0020$; SSZD Model: $p < 0.0001$), and length of hind foot (SSZ Model: $p < 0.0001$; SSZD Model: $p < 0.0001$) between zones of sympatry and near sympatry in comparison to zones of allopatry. Based on the results of both models *N. fuscipes* exhibited a statistically significant divergence from *N. macrotis* with regard to breadth of rostrum (SSZ Model: $p < 0.0001$; SSZD Model: $p < 0.0001$) between zones of sympatry and near sympatry in comparison to zones of allopatry.

The results of convergence in body-size, length of ear, and length of hind foot and the divergence in breadth of rostrum were more statististically significant in the second model (SSZD Model) than in the first model (SSZ Model). Additionally, the trends of convergence and divergence were more statistically significant between zones of sympatry and near sympatry than in comparison to zones of sympatry and allopatry. Refer to Table 5 below for a summary of all test statistics for contrasts of zones of

sympatry and near sympatry in comparison to zones of allopatry by species for the species-by-zone interaction. For graphical representation, compare zones of sympatry and near sympatry to zones allopatry between SSZ Model and SSZD Model in Figures 5 through 9.

TABLE 5. CONTRASTING ZONES OF SYMPATRY AND NEAR SYMPATRY IN COMPARISON TO ZONES OF ALLOPATRY BY SPECIES FOR THE SPECIES-BY-ZONE INTERACTION WITH A COMPARISON OF MODELS

Model	Character Trait	SS	DenDF	F Ratio	Prob > F
SSZ	Weight Log10 (g)	0.065313951	580	9.2027	0.0001
SSZD	Weight Log10 (g)	0.048157785	579	7.0107	0.0010
SSZ	Ear (mm)	60.657729	556	6.2784	0.0020
SSZD	Ear (mm)	88.66466544	555	9.27	0.0001
SSZ	Rostrum (mm)	19.55726719	407	17.7746	<0.0001
SSZD	Rostrum (mm)	19.40904132	406	17.6618	<0.0001
SSZ	Hind Foot (mm)	165.2889057	556	18.2618	<0.0001
SSZD	Hind Foot (mm)	133.7810756	555	14.7655	<0.0001
SSZ	Tail (mm)	469.2788893	562	1.5879	0.2053
SSZD	Tail (mm)	943.5974393	561	3.2593	0.0391

DISCUSSION

Areas of secondary contact between sister lineages of *Neotoma* have provided a unique opportunity to understand the mechanisms that contribute to the generation and maintenance of species boundaries. The transect along the Nacimeinto River has provided a system in which to examine how ecological, and morphological isolating mechanisms may contribute to the genetic or phenotypic distinctiveness within and between species. I confirmed that the two sister taxa are morphologically distinct and that the phallus morphology is indeed a reliable means of indentifying adult male woodrats as to species. The overall trend of divergence in breadth of rostrum in *N. fuscipes* in regions of sympatry along the transect on Nacimiento River was identified. Based on the results of the SSZ Model, the overall convergence in body-size and length of hind foot of *N. macrotis* towards that of *N. fuscipes* in sympatric and near sympatric regions of the transect was identified. Alternatively, based on the results of the SSZD Model, the overall convergence in length of ear and length of hind foot of *N. macrotis* towards that of *N. fuscipes* and in sympatric and near sympatric regions of the transect were identified. The divergence of both species with regard to body-size was also observed. By observing morphological character shifts between sympatric populations and allopatric populations of woodrats, I was able to observe and quantify ecological processes such as exploitative and contest competition. The allometric patterns of morphological variation in body-size and morphological characters are consistent with expectations of a combination of contest and exploitative competition.

Diagnostic Characteristics

The allopatric populations of sister taxa *N. fuscipes* and *N. macrotis* exhibited a statististically significant species-specific homogeneous suites of character traits. Based on the results of the SSZ Model, *N. fuscipes* was statistically significantly larger than *N. macrotis* with regard to body-size (Table 2). In areas of allopatry, the two sister species are distinct and diagnosable in all five measured characters. However, when accounting for clinal variation within the system there was no statistically significant difference between the two species with regard to the body-size, the breadth of rostrum and the length of tail (Table 2). In other words, variation in these traits is equally explainable by distance, which is regarded here as a proxy for clinal environmental variation. When accounting for environmental variation, *N. fuscipes* remained statistically significantly larger than *N. macrotis* with regard to length of ear and length of hind foot (Table 2). Therefore, the distinctions in body-size, breadth of rostrum, and length of tail observed between the two species in allopatry may be a function of clinal variation, while distinctions between length of ear and length of hind foot appear to be species-specific and genetically linked. Notably, environmental variation may be confounded with variation associated by species-specific variation.

Convergence and Divergence via Allometric Re-patterning

TABLE 6. SUMMARY OF DIVERGENE AND CONVERGENCE RESULTS FOR ZONES SYMPATRY AND ALLOPATRY A COMPARISON OF MODELS

Character Trait	SSZ Model	SSZD Model
Body-size (Weight log10 [g])	Convergence	Divergence
Length of Ear (mm)	--	Convergence
Breadth of Rostrum (mm)	Divergence	Divergence
Length of Hind foot(mm)	Convergence	Convergence
Length of Tail (mm)	--	--

Neotoma macrotis exhibited statistically significant convergence towards *N. fuscipes* with regard to body-size and length of hind foot (Table 3) between zones of sympatry and allopatry. When accounting for environmental clinal variation *N. macrotis* exhibited statistically significant convergence towards *N. fuscipes* with regard to length of ear (Table 3) between zones of sympatry and allopatry. Between zones of sympatry and allopatry, *N. fuscipes* exhibited statistically significant divergence in breadth of rostrum from *N. macrotis* (Table 3). These findings support the hypothesis that allometric shifts in external character traits were observed within the zone of sympatry between the two species. Specifically, *N. macrotis* is approaching the body-size of *N. fuscipes* observable in body-size, length of ear, and length of hind foot. Additionally, the variation in size and shape supports the hypothesis of an allometric shift in size-independent character traits.

A Narrow, Dispersal-Independent Clinal Pattern

The results of length of ear, and length of hind foot, and the divergence in breadth of rostrum were more statistically significant in the second model (SSZD Model) than in the first model (SSZ Model) (Table 4). Convergence in body-size was detected in the SSZ Model, while a divergence in body-size was detected in the SSZD Model. Additionally, the trends of convergence and divergence were more statistically significant between zones of sympatry and near sympatry than in comparison to zones of sympatry and allopatry. These findings support the hypothesis of a narrow cline dispersal-independent cline or contact zone.

Competition and Convergence versus Divergence

The allometric re-patterning observed in the convergence in body-size, length of ear, and length of hind foot infer contest competition between the two species in sympatry. The allometric re-patterning observed in the divergence in breadth of rostrum supports the hypothesis of exploitative competition between the two species within the zone of sympatry. In the SSZ Model, I noted a convergence in body-size. In both the SSZ Model and the SSZD Model, I noted a convergence length of hind foot as well as a divergence in the breadth of rostrum. In the SSZD Model, a divergence in body-size and a convergence in length of ear were detected. While no sign of an allometric shift in length of tails was observed in either model (SSZ Model and SSZD Model).

Evidence of morphological character displacement within the two congeners suggests that inter-specific competitive interactions are occurring. Specifically, evidence of allometric size-independent shifts in character traits (*i.e.* such as breadth of rostrum, length of hind foot, and length of ear) make for a compelling story by inferring an ecological relationship between the sister taxa. In the SSZ Model and the SSZD Model, I observe that the body-size of *N. macrotis* approaches that of *N. fuscipes* and that this effect is more significant when I account for environmental variation. Also, in both models I see that rostrum breadth of *N. fuscipes* diverges significantly from that of *N. macrotis* and from that of a predicted species-by-distance trend. As I hypothesized, I regard convergence in character traits and body-size to be indicative of the presence of heightened contest competition within the contact zone, while a divergence in character traits (*i.e.* breadth of rostum) I regard as indicative of heightened exploitative competition within the contact zone (Tables 4 and 5). Specifically, a divergence in mandibular

character traits could be indicative of a divergence in diet. Hence I conclude that niche partitioning within the contact zone is occurring and that contest competition between the congeners is also taking place.

According to Gause's Principle no two species with identical requirements may continue to exist together (Volpe and Rosenbaum 2000, p. 148). Competitive interaction should ultimately result in a reduction in competition through differential specialization via niche diversification or niche partitioning as a result of both stabilizing and disruptive selection and convergence and divergence respectively (Volpe and Rosenbaum 2000, p. 148). This mechanism of divergence is highly likely here. Additionally, coexistence and ability to persist in sympatry, following secondary contact of parental and derived populations, may be considered the final step in completion of speciation (West-Eberhard 1989). Phenotypic plasticity allows for adjustments in mean species-specific character traits associated with niche utilization and competition pressure. However, a genetic component is necessary to maintain differences between means of different species (Schluter 2000).

The most common pattern detected is exaggerated divergence in sympatry, whereby phenotypic differences between two species are greater where the species coexist in sympatry than when they occur separately in allopatry (Schluter 2000). According to Charles Darwin, competition is most severe between those individuals that are the most similar to each other as such individuals are normally most similar in resource use and in associated traits (Lack 1947; Pfennig and Pfennig 2014). In support of Charles Darwin's conclusions, a trend of allometric divergence in breadth of rostrum is observed within the contact zone. Asymmetric divergence, as observed in the divergence

of breadth of rostrum in *N. fuscipes*, may indicate that *N. fuscipes* is experiencing increased levels of competition within the contact zone and is being further displaced than *N. macrotis.* If indeed *N. fuscipes* is experiencing the majority of the ecological niche displacement and having to seek out a different diet, then this may explain the divergence in cranial measurement of breadth of rostrum. Evolution in cranial morphology, specifically rostrum morphology, is thought to be driven by diet (Matocq and Murphy 2007). Matocq and Murphy (2007) note that the length of the rostrum may serve to determine the leverage action during the gnawing process and that changes in its length will impact incisal bite force (Satoh 1997 as cited in Matocq and Murphy 2007). In comparison, the breadth of rostrum may serve as a similar proxy for differences in diet.

When resources differ in essential nutrients, as may be true for herbivores such as woodrats, character displacement may be more complex and may result in convergence of specific character traits (Abrams and Matsuda 1994, Schluter 2000). Following this line of thought, it is worth noting that *N. macrotis* converges towards *N. fuscipes* with regard to weight, length of ear, and length of hind foot. Notably, weight has been regarded as a proxy for body-size. Often the measurement of total length has also been used to gauge body-size. If character traits that evolve in sympatry lead to a selective disadvantage in allopatry, then character traits that evolve in response to heterospecifics should theretically remain localized in sympatry (Pfennig and Pfennig 2005). This would result in narrow, dispersal-independent contact zone. The most commonly observed pattern of character displacement is that of divergent character traits in sympatry and allopatry. Observable trends of divergence in character traits suggest that the fitness

advantages in sympatric populations may be a common feature of character displacement (Pfennig and Pfennig 2005).

The Sierra Nevada Contact Zone and the Nacimiento Contact Zone

The presence of hybrid individuals within the contact zone may influence the system by adding an additional level of competition associated with intermediate or hybrid phenotypes within the system that was not explored in this study. The next step will be to compare the hybrid individuals within the system to *N. macrotis* and *N. fuscipes.* This will help to shed light on the role that hybrids play within the system and on how much these individuals play a part in direct and indirect competition.

Matocq and Murphy's (2007) findings demonstrated that competition may drive both divergence and convergence in different morphological traits within sister species. By examining a suite of morphological character traits across a contact zone, I observed a more comprehensive picture of potential ecological and evolutionary outcomes. Much of my study was based on attempting to replicate Matocq and Murphy's (2007) analysis in the Sierra Nevada. However, by examining external morphological character traits, or measurements that may be taken in the field, I found that my research provides a different approach to quantifying and qualifying character displacement.

By choosing to use the SSZ Model and SSZD Model, I was potentially assessing the effects of environment variation on a phenotypic cline. By creating SSZD Model, I was able to account for the confounded effects of distance *and* species along the transect. Once I have accounted for variation associated with species, sex, and differences associated with environment (or distance), I am no longer assessing phenotypic variation that may be associated with a natural environmental cline. Consequently, I am confident

that I am more precisely assessing variation associated with the effects of heightened competition within the contact zone. The first model (SSZ Model) assumes a homogeneous environment across the transect, or zones, and does not account for a natural environmental or a distance effect. Environmental variation may be associated with differences in micro-climates, temperature, habitat structure, habitat type, or a combination of these factors along the 20 kilometer transect. As Smith et al. (1995) states, morphological variation associated with environmental factors along the transect should not be ignored. Therefore, the second model (SSZD Model) includes an additional variable that accounts for distance (distance in meters from the central feature of the contact zone). Fundamentally, the first model assumes a homogeneous environment and the second model allows for a heterogeneous environment. Additionally, both models allow for non-linear data and both test whether convergence or divergence is occurring for each individual character trait along the transect.

My results of convergence of body-size and divergence in cranial measurements (breadth of rostrum) are consistent with Matocq and Murphy's (2007) findings in the western Sierra Nevada. Not only are these results consistent with Matocq and Murphy's findings, but the fact that *N. macrotis* body-size approaches that of *N. fuscipes* is also consistent. By testing my hypothesis with SSZ Model I may compare my findings directly to Matocq and Murphy (2007). However, when comparing the two models, I see that the convergence of body-size is less significant when I account for expectations of body-size using a model that allows for environmental variation (SSZD Model). I see a notable increase in the significance of divergence in breadth of rostrum in *N. fuscipes* when I account for phenotypic variation using a model that allows for a natural

environmental cline (SSZ Model versus SSZD Model). Additionally, I may compare my findings to other studies on character displacement (Adams 2004; Adams and Rohlf 2000; Hayes and Richmond 1993; Klingenberg et al. 2001; Matocq and Murphy 2007; Patton et al. 2014; Pfennig and Murphy 2003; Weiser and Kaspari 2006). With the SSZD Model I may separate the otherwise confounded character displacement from natural environmental variation.

Clinal Variation in Regard to a Contact Zone – Ecological or Evolutionary Responses

Scientists have often relied on Principal Components Analysis (PCA) to test for character displacement by partitioning correlations among several morphological dimensions considered simultaneously (Adams 2004; Adams and Rohlf 2000; Hayes and Richmond 1993; Klingenberg et al. 2001; Matocq and Murphy 2007; Patton et al. 2014; Pfennig and Murphy 2003; Weiser and Kaspari 2006). Variation among the dimensions is expressed on a reduced number of synthetic axes (Gould 1966).

Furthermore, including all the morphological variables as eigenvalues will limit the ability to interpret the divergence and convergences of individual morphological character traits. For all these reasons I chose to utilize the general linear model that accounted for distance along the transect (SSZD Model). Not only am I able to partition out any variation associated with a natural environmental cline that co-varies with distance (clinal), but I am also able to qualify direction and quantify the amount of the character displacement for each character trait. Therefore, I am not simply examining the broader categories of size and shape, but I am able to consider convergence and divergence, as well as isometry and allometry, across each of the mensural characters. The benefits of each method will come down to whether one thinks that morphological

variation that is confounded (species and distance) is, or is not, part of the clinal variation associated with a contact zone. Alternatively, it comes down to making the assumption that the environment is homogeneous across the entire contact zone, or that it can be heterogeneous. Clearly, here, I have been willing to attribute some of what would otherwise be regarded as variation to an evolutionary cline of that of an ecological cline.

Further Research

Matocq and Murphy (2007) recommend analyzing the diets of *N. fuscipes* and *N. macrotis* to examine the relationship between character trait and diet in the craniodentally displaced and nondisplaced species. For a concurrent study within this system, I helped collect hair and fecal samples from woodrats as well as vegetation samples within transects along the contact zone. Comparing isotope signatures of vegetation with samples from woodrats may eventually provide additional evidence that the species may be niche partitioning. Additionally, examining habitat preference and dominant vegetation types associated with middens may illuminate how variable the environment along the transect actually is. Examining capture data of woodrats to better determine the home range for each species may allow for interpretations of dispersal-independent clinal variation to be further tested.

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APPENDICES

APPENDIX A – DATA OUTPUT FROM JMP Pro© -- SSZ MODEL

Fit Group

Response Weight Log10

Summary of Fit

RSquare	0.380084
RSquare Adj	0.372603
Root Mean Square Error	0.05957
Mean of Response	2.47277
Observations (or Sum Wgts)	588

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	1.2619367	0.180277	50.8016
Error	580	2.0582126	0.003549	Prob > F
C. Total	587	3.3201493		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.4741341	0.002666	928.19	<.0001*
Sex[Female]	-0.027716	0.002467	-11.23	<.0001*
Species[macrotis]	-0.036988	0.002666	-13.88	<.0001*
Zone[Sympatry]	-0.001008	0.003713	-0.27	0.7861
Zone[Near Sympatry]	0.011511	0.003505	3.28	0.0011*
Species[macrotis]*Zone[Sympatry]	0.0049585	0.003713	1.34	0.1822
Species[macrotis]*Zone[Near Sympatry]	0.006248	0.003505	1.78	0.0752
Species[macrotis]*Sex[Female]	0.012864	0.002467	5.21	<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	0.44772222	126.1672	<.0001*
Species	1	1	0.68331357	192.5563	<.0001*
Zone	2	2	0.04197691	5.9145	0.0029*
Species*Zone	2	2	0.02771461	3.9050	0.0207*
Species*Sex	1	1	0.09645024	27.1795	<.0001*

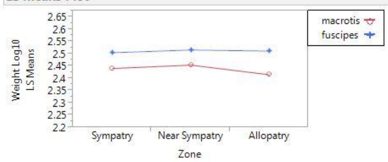
Effect Details

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	2.4410961	0.00744938
macrotis,Near Sympatry	2.4549047	0.00490211
macrotis,Allopatry	2.4154363	0.00615971
fuscipes,Sympatry	2.5051559	0.00501134
fuscipes,Near Sympatry	2.5163855	0.00621499
fuscipes,Allopatry	2.5118260	0.00859826

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	-0.096
Std Error	0.0106
t Ratio	-9.113
Prob>|t|	1e-18
SS	0.2947

SS	NumDF	DenDF	F Ratio	Prob > F
0.295	1	580	83.0500	<.0001*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	0.0257	-0.007
Std Error	0.0097	0.01
t Ratio	2.6572	-0.67
Prob>|t|	0.0081	0.503
SS	0.0251	0.0016

SS	NumDF	DenDF	F Ratio	Prob > F
0.027	2	580	3.7551	0.0240*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	-0.033	0.0011
Std Error	0.0076	0.0095
t Ratio	-4.289	0.1113
Prob>|t|	2.1e-5	0.9114
SS	0.0653	4.4e-5

SS	NumDF	DenDF	F Ratio	Prob > F
0.065	2	580	9.2027	0.0001*

Response Ear (mm)

Summary of Fit

RSquare	0.254128
RSquare Adj	0.244737
Root Mean Square Error	2.197883
Mean of Response	36.17376
Observations (or Sum Wgts)	564

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	915.1075	130.730	27.0623
Error	556	2685.8642	4.831	Prob > F
C. Total	563	3600.9716		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	36.322232	0.100767	360.46	<.0001*
Sex[Female]	-0.399733	0.09309	-4.29	<.0001*
Species[macrotis]	-1.201179	0.100767	-11.92	<.0001*
Zone[Sympatry]	-0.031595	0.140105	-0.23	0.8217
Zone[Near Sympatry]	-0.406907	0.133483	-3.05	0.0024*
Species[macrotis]*Zone[Sympatry]	0.0216966	0.140105	0.15	0.8770
Species[macrotis]*Zone[Near Sympatry]	0.3859544	0.133483	2.89	0.0040*
Species[macrotis]*Sex[Female]	0.3265375	0.09309	3.51	0.0005*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	89.07154	18.4387	<.0001*
Species	1	1	686.41969	142.0955	<.0001*
Zone	2	2	55.64907	5.7599	0.0033*
Species*Zone	2	2	49.21261	5.0937	0.0064*
Species*Sex	1	1	59.43813	12.3043	0.0005*

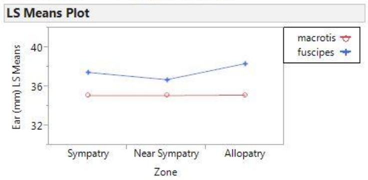
Effect Details

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	35.111154	0.28148065
macrotis,Near Sympatry	35.100100	0.18329520
macrotis,Allopatry	35.151905	0.22997313
fuscipes,Sympatry	37.470119	0.18715267
fuscipes,Near Sympatry	36.730550	0.24280504
fuscipes,Allopatry	38.369565	0.32406021

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	-3.218
Std Error	0.3974
t Ratio	-8.097
Prob>|t|	4e-15
SS	316.74

SS	NumDF	DenDF	F Ratio	Prob > F
316.7	1	556	65.5678	<.0001*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	-0.041	-0.899
Std Error	0.3631	0.3742
t Ratio	-0.112	-2.404
Prob>|t|	0.9107	0.0166
SS	0.0608	27.906

SS	NumDF	DenDF	F Ratio	Prob > F
27.97	2	556	2.8947	0.0561

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	0.0463	1.2692
Std Error	0.2844	0.3586
t Ratio	0.1627	3.5398
Prob>|t|	0.8708	0.0004
SS	0.128	60.53

SS	NumDF	DenDF	F Ratio	Prob > F
60.66	2	556	6.2784	0.0020*

Response Rostrum (mm)

Summary of Fit

RSquare	0.269869
RSquare Adj	0.257311
Root Mean Square Error	0.741718
Mean of Response	9.076361
Observations (or Sum Wgts)	415

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	82.76068	11.8230	21.4906
Error	407	223.90912	0.5501	Prob > F
C. Total	414	306.66981		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	9.0827666	0.038993	232.93	<.0001*
Sex[Female]	-0.11367	0.03685	-3.08	0.0022*
Species[macrotis]	-0.341408	0.038993	-8.76	<.0001*
Zone[Sympatry]	0.1401895	0.056435	2.48	0.0134*
Zone[Near Sympatry]	0.1804484	0.052145	3.46	0.0006*
Species[macrotis]*Zone[Sympatry]	-0.053041	0.056435	-0.94	0.3478
Species[macrotis]*Zone[Near Sympatry]	-0.117519	0.052145	-2.25	0.0247*
Species[macrotis]*Sex[Female]	0.049922	0.03685	1.35	0.1763

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	5.234614	9.5150	0.0022*
Species	1	1	42.175054	76.6617	<.0001*
Zone	2	2	18.149149	16.4949	<.0001*
Species*Zone	2	2	5.511518	5.0091	0.0071*
Species*Sex	1	1	1.009671	1.8353	0.1763

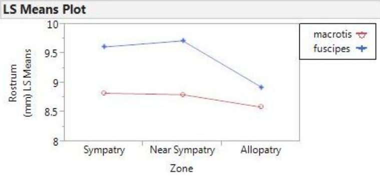
Effect Details

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	8.8285063	0.11589288
macrotis,Near Sympatry	8.8042876	0.07188303
macrotis,Allopatry	8.5912808	0.08222539
fuscipes,Sympatry	9.6174060	0.08076297
fuscipes,Near Sympatry	9.7221425	0.09656790
fuscipes,Allopatry	8.9329766	0.11602973

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	-0.342
Std Error	0.1422
t Ratio	-2.403
Prob>|t|	0.0167
SS	3.1761

SS	NumDF	DenDF	F Ratio	Prob > F
3.176	1	407	5.7732	0.0167*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	0.2372	0.6844
Std Error	0.1419	0.1417
t Ratio	1.6716	4.8299
Prob>|t|	0.0954	1.9e-6
SS	1.5372	12.834

SS	NumDF	DenDF	F Ratio	Prob > F
14.37	2	407	13.0613	<.0001*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	-0.225	-0.737
Std Error	0.1066	0.1321
t Ratio	-2.112	-5.576
Prob>|t|	0.0353	4.5e-8
SS	2.4548	17.102

SS	NumDF	DenDF	F Ratio	Prob > F
19.56	2	407	17.7746	<.0001*

Response Hind Foot (mm)

Summary of Fit

RSquare	0.301921
RSquare Adj	0.293132
Root Mean Square Error	2.127333
Mean of Response	39.21277
Observations (or Sum Wgts)	564

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	1088.2646	155.466	34.3531
Error	556	2516.2035	4.526	Prob > F
C. Total	563	3604.4681		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	39.188215	0.096901	404.41	<.0001*
Sex[Female]	-0.628915	0.08998	-6.99	<.0001*
Species[macrotis]	-1.028611	0.096901	-10.62	<.0001*
Zone[Sympatry]	0.7214692	0.134627	5.36	<.0001*
Zone[Near Sympatry]	0.0288943	0.128771	0.22	0.8225
Species[macrotis]*Zone[Sympatry]	0.0741936	0.134627	0.55	0.5818
Species[macrotis]*Zone[Near Sympatry]	0.2301781	0.128771	1.79	0.0744
Species[macrotis]*Sex[Female]	0.0228533	0.08998	0.25	0.7996

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	221.08889	48.8535	<.0001*
Species	1	1	509.93343	112.6789	<.0001*
Zone	2	2	157.27695	17.3766	<.0001*
Species*Zone	2	2	22.52086	2.4882	0.0840
Species*Sex	1	1	0.29193	0.0645	0.7996

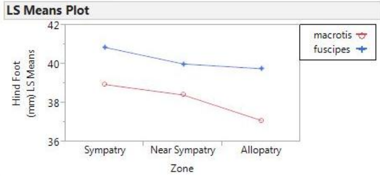
Effect Details

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	38.955267	0.26808323
macrotis,Near Sympatry	38.418676	0.17562219
macrotis,Allopatry	37.104869	0.22601247
fuscipes,Sympatry	40.864101	0.18267120
fuscipes,Near Sympatry	40.015541	0.23650849
fuscipes,Allopatry	39.770833	0.30705408

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	-2.666
Std Error	0.3813
t Ratio	-6.992
Prob>|t|	8e-12
SS	221.27

SS	NumDF	DenDF	F Ratio	Prob > F
221.3	1	556	48.8936	<.0001*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	1.8504	1.0933
Std Error	0.3504	0.3573
t Ratio	5.281	3.0599
Prob>|t|	1.8e-7	0.0023
SS	126.21	42.374

SS	NumDF	DenDF	F Ratio	Prob > F
168.6	2	556	18.6262	<.0001*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	-1.582	-0.669
Std Error	0.2767	0.3415
t Ratio	-5.717	-1.959
Prob>|t|	1.8e-8	0.0506
SS	147.93	17.363

SS	NumDF	DenDF	F Ratio	Prob > F
165.3	2	556	18.2618	<.0001*

Response Tail (mm)

Summary of Fit

RSquare	0.188675
RSquare Adj	0.17857
Root Mean Square Error	12.15609
Mean of Response	201.7892
Observations (or Sum Wgts)	570

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	19312.74	2758.96	18.6706
Error	562	83047.05	147.77	Prob > F
C. Total	569	102359.79		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	202.50073	0.552969	366.21	<.0001*
Sex[Female]	-0.540259	0.511715	-1.06	0.2915
Species[macrotis]	-5.915772	0.552969	-10.70	<.0001*
Zone[Sympatry]	-0.083427	0.768966	-0.11	0.9136
Zone[Near Sympatry]	-0.179979	0.733459	-0.25	0.8062
Species[macrotis]*Zone[Sympatry]	1.6383644	0.768966	2.13	0.0336*
Species[macrotis]*Zone[Near Sympatry]	-0.149654	0.733459	-0.20	0.8384
Species[macrotis]*Sex[Female]	0.1854343	0.511715	0.36	0.7172

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	164.716	1.1147	0.2915
Species	1	1	16912.536	114.4513	<.0001*
Zone	2	2	15.969	0.0540	0.9474
Species*Zone	2	2	735.060	2.4872	0.0841
Species*Sex	1	1	19.405	0.1313	0.7172

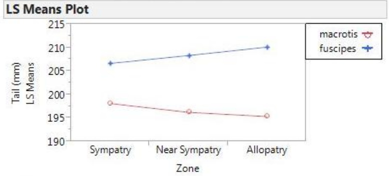
Effect Details

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	198.13989	1.5444941
macrotis,Near Sympatry	196.25532	0.9999500
macrotis,Allopatry	195.35965	1.2848032
fuscipes,Sympatry	206.69471	1.0300556
fuscipes,Near Sympatry	208.38617	1.3435141
fuscipes,Allopatry	210.16861	1.7545806

LS Means Plot



Contrast

SS	NumDF	DenDF	F Ratio	Prob > F
6852	1	562	46.3719	<.0001*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	2.7802	-3.474
Std Error	2.0069	2.0346
t Ratio	1.3853	-1.707
Prob>|t|	0.1665	0.0883
SS	283.6	430.79

SS	NumDF	DenDF	F Ratio	Prob > F
714.4	2	562	2.4172	0.0901

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	-1.838	2.6282
Std Error	1.578	1.9486
t Ratio	-1.165	1.3487
Prob>|t|	0.2446	0.178
SS	200.47	268.81

SS	NumDF	DenDF	F Ratio	Prob > F
469.3	2	562	1.5879	0.2053

APPENDIX B – DATA OUTPUT FROM JMP Pro© -- SSZD MODEL

Fit Group

Response Weight Log10

Summary of Fit

RSquare	0.401038
RSquare Adj	0.392762
Root Mean Square Error	0.058606
Mean of Response	2.47277
Observations (or Sum Wgts)	588

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	1.3315070	0.166438	48.4591
Error	579	1.9886423	0.003435	Prob > F
C. Total	587	3.3201493		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.4738273	0.002623	943.04	<.0001*
Sex[Female]	-0.027949	0.002428	-11.51	<.0001*
Species[macrotis]	-0.014123	0.005717	-2.47	0.0138*
Species[macrotis]*Sex[Female]	0.0118805	0.002437	4.87	<.0001*
Distance	3.3537e-6	7.452e-7	4.50	<.0001*
Zone[Sympatry]	-0.001003	0.003653	-0.27	0.7837
Zone[Near Sympatry]	0.0114368	0.003449	3.32	0.0010*
Species[macrotis]*Zone[Sympatry]	-0.01733	0.006154	-2.82	0.0050*
Species[macrotis]*Zone[Near Sympatry]	-0.010078	0.005005	-2.01	0.0445*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	0.45506930	132.4950	<.0001*
Species	1	1	0.02095783	6.1019	0.0138*
Species*Sex	1	1	0.08160482	23.7595	<.0001*
Distance	1	1	0.06957034	20.2556	<.0001*
Zone	2	2	0.04143373	6.0318	0.0026*
Species*Zone	2	2	0.02993464	4.3578	0.0132*

Effect Details

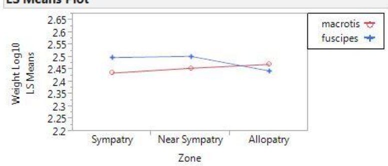
Distance

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	2.4362548	0.00740724
macrotis,Near Sympatry	2.4559462	0.00482826
macrotis,Allopatry	2.4715619	0.01386504
fuscipes,Sympatry	2.4991607	0.00510696
fuscipes,Near Sympatry	2.5043489	0.00667364
fuscipes,Allopatry	2.4449918	0.01709025

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	0.0266
Std Error	0.0292
t Ratio	0.9088
Prob>|t|	0.3638
SS	0.0028

SS	NumDF	DenDF	F Ratio	Prob > F
0.003	1	579	0.8260	0.3638

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	-0.035	0.0542
Std Error	0.0165	0.0167
t Ratio	-2.134	3.2454
Prob>|t|	0.0333	0.0012
SS	0.0156	0.0362

SS	NumDF	DenDF	F Ratio	Prob > F
0.036	2	579	5.2665	0.0054*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	0.0255	-0.057
Std Error	0.0149	0.0159
t Ratio	1.7088	-3.575
Prob>|t|	0.088	0.0004
SS	0.01	0.0439

SS	NumDF	DenDF	F Ratio	Prob > F
0.048	2	579	7.0107	0.0010*

Response Ear (mm)

Summary of Fit

RSquare	0.262923
RSquare Adj	0.252298
Root Mean Square Error	2.186854
Mean of Response	36.17376
Observations (or Sum Wgts)	564

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	946.7783	118.347	24.7468
Error	555	2654.1933	4.782	Prob > F
C. Total	563	3600.9716		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	36.332159	0.100335	362.11	<.0001*
Sex[Female]	-0.396687	0.092631	-4.28	<.0001*
Species[macrotis]	-1.709	0.221343	-7.72	<.0001*
Species[macrotis]*Sex[Female]	0.3473076	0.092974	3.74	0.0002*
Distance	-7.337e-5	2.851e-5	-2.57	0.0103*
Zone[Sympatry]	-0.034806	0.139407	-0.25	0.8029
Zone[Near Sympatry]	-0.409373	0.132817	-3.08	0.0022*
Species[macrotis]*Zone[Sympatry]	0.5163072	0.237431	2.17	0.0301*
Species[macrotis]*Zone[Near Sympatry]	0.7486746	0.193665	3.87	0.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	87.70481	18.3393	<.0001*
Species	1	1	285.09660	59.6146	<.0001*
Species*Sex	1	1	66.73326	13.9541	0.0002*
Distance	1	1	31.67085	6.6225	0.0103*
Zone	2	2	56.65767	5.9236	0.0028*
Species*Zone	2	2	72.87154	7.6188	0.0005*

Effect Details

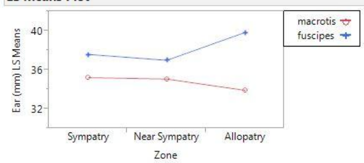
Distance

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	35.222653	0.28339971
macrotis,Near Sympatry	35.080453	0.18253512
macrotis,Allopatry	33.920349	0.53045831
fuscipes,Sympatry	37.608038	0.19377241
fuscipes,Near Sympatry	37.001104	0.26347162
fuscipes,Allopatry	39.868312	0.66569408

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	-5.948
Std Error	1.1322
t Ratio	-5.253
Prob>|t|	2.1e-7
SS	131.98

SS	NumDF	DenDF	F Ratio	Prob > F
132	1	555	27.5969	<.0001*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	1.3023	-2.26
Std Error	0.6348	0.6467
t Ratio	2.0516	-3.495
Prob>|t|	0.0407	0.0005
SS	20.13	58.412

SS	NumDF	DenDF	F Ratio	Prob > F
59.19	2	555	6.1880	0.0022*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	-1.231	2.5637
Std Error	0.5714	0.6167
t Ratio	-2.155	4.1572
Prob>|t|	0.0316	3.7e-5
SS	22.205	82.65

SS	NumDF	DenDF	F Ratio	Prob > F
88.66	2	555	9.2700	0.0001*

Response Rostrum (mm)

Summary of Fit

RSquare	0.272565
RSquare Adj	0.258231
Root Mean Square Error	0.741258
Mean of Response	9.076361
Observations (or Sum Wgts)	415

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	83.58747	10.4484	19.0157
Error	406	223.08233	0.5495	Prob > F
C. Total	414	306.66981		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	9.0801181	0.039028	232.65	<.0001*
Sex[Female]	-0.115968	0.036875	-3.14	0.0018*
Species[macrotis]	-0.245877	0.087084	-2.82	0.0050*
Species[macrotis]*Sex[Female]	0.0467147	0.03692	1.27	0.2065
Distance	1.3183e-5	1.075e-5	1.23	0.2207
Zone[Sympatry]	0.1412709	0.056407	2.50	0.0127*
Zone[Near Sympatry]	0.182298	0.052134	3.50	0.0005*
Species[macrotis]*Zone[Sympatry]	-0.146931	0.095075	-1.55	0.1230
Species[macrotis]*Zone[Near Sympatry]	-0.186355	0.076582	-2.43	0.0154*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	5.434344	9.8903	0.0018*
Species	1	1	4.380257	7.9719	0.0050*
Species*Sex	1	1	0.879672	1.6010	0.2065
Distance	1	1	0.826790	1.5047	0.2207
Zone	2	2	18.452239	16.7911	<.0001*
Species*Zone	2	2	3.460332	3.1488	0.0440*

Effect Details

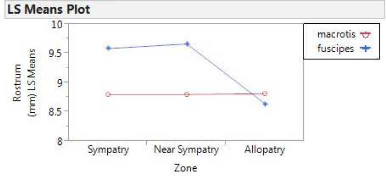
Distance

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	8.8022464	0.11778286
macrotis,Near Sympatry	8.8038493	0.07183939
macrotis,Allopatry	8.8176226	0.20198815
fuscipes,Sympatry	9.5878620	0.08422974
fuscipes,Near Sympatry	9.6683133	0.10601637
fuscipes,Allopatry	8.6428060	0.26344400

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	0.1748
Std Error	0.4444
t Ratio	0.3934
Prob>|t|	0.6943
SS	0.085

SS	NumDF	DenDF	F Ratio	Prob > F
0.085	1	406	0.1547	0.6943

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	-0.015	0.9451
Std Error	0.25	0.2553
t Ratio	-0.061	3.7012
Prob>|t|	0.951	0.0002
SS	0.0021	7.527

SS	NumDF	DenDF	F Ratio	Prob > F
13.87	2	406	12.6236	<.0001*

Contrast

SS	NumDF	DenDF	F Ratio	Prob > F
19.41	2	406	17.6618	<.0001*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	0.0146	-0.985
Std Error	0.2225	0.2418
t Ratio	0.0655	-4.075
Prob>|t|	0.9478	0.0001
SS	0.0024	9.122

SS	NumDF	DenDF	F Ratio	Prob > F
19.41	2	406	17.6618	<.0001*

Response Hind Foot (mm)

Summary of Fit

RSquare	0.302463
RSquare Adj	0.292408
Root Mean Square Error	2.128422
Mean of Response	39.21277
Observations (or Sum Wgts)	564

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	1090.2175	136.277	30.0821
Error	555	2514.2505	4.530	Prob > F
C. Total	563	3604.4681		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	39.188688	0.096954	404.20	<.0001*
Sex[Female]	-0.627699	0.090045	-6.97	<.0001*
Species[macrotis]	-1.153817	0.213924	-5.39	<.0001*
Species[macrotis]*Sex[Female]	0.0286428	0.090457	0.32	0.7516
Distance	-1.817e-5	2.767e-5	-0.66	0.5117
Zone[Sympatry]	0.722546	0.134706	5.36	<.0001*
Zone[Near Sympatry]	0.030319	0.128855	0.24	0.8141
Species[macrotis]*Zone[Sympatry]	0.1963352	0.22967	0.85	0.3930
Species[macrotis]*Zone[Near Sympatry]	0.3192492	0.187088	1.71	0.0885

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	220.14103	48.5943	<.0001*
Species	1	1	131.78620	29.0907	<.0001*
Species*Sex	1	1	0.45422	0.1003	0.7516
Distance	1	1	1.95297	0.4311	0.5117
Zone	2	2	157.93763	17.4317	<.0001*
Species*Zone	2	2	13.26585	1.4642	0.2322

Effect Details

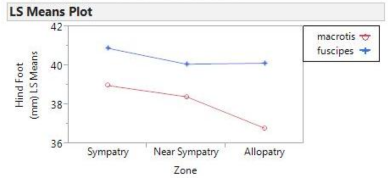
Distance

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	38.981626	0.27120826
macrotis,Near Sympatry	38.412313	0.17597919
macrotis,Allopatry	36.794295	0.52428659
fuscipes,Sympatry	40.896589	0.18934445
fuscipes,Near Sympatry	40.081448	0.25703965
fuscipes,Allopatry	40.133098	0.63150420

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	-3.339
Std Error	1.0935
t Ratio	-3.053
Prob>|t|	0.0024
SS	42.237

SS	NumDF	DenDF	F Ratio	Prob > F
42.24	1	555	9.3236	0.0024*

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	2.1873	0.7635
Std Error	0.6215	0.6165
t Ratio	3.5196	1.2385
Prob>|t|	0.0005	0.2161
SS	56.118	6.9484

SS	NumDF	DenDF	F Ratio	Prob > F
163.7	2	555	18.0715	<.0001*

Contrast

Test Detail

macrotis,Sympatry	-0.5	0
macrotis,Near Sympatry	-0.5	0
macrotis,Allopatry	1	0
fuscipes,Sympatry	0	-0.5
fuscipes,Near Sympatry	0	-0.5
fuscipes,Allopatry	0	1
Estimate	-1.903	-0.356
Std Error	0.5613	0.5866
t Ratio	-3.39	-0.607
Prob>|t|	0.0007	0.5443
SS	52.058	1.6677

SS	NumDF	DenDF	F Ratio	Prob > F
133.8	2	555	14.7655	<.0001*

Response Tail (mm)

Summary of Fit

RSquare	0.206654
RSquare Adj	0.19534
Root Mean Square Error	12.03136
Mean of Response	201.7892
Observations (or Sum Wgts)	570

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	21153.03	2644.13	18.2664
Error	561	81206.75	144.75	Prob > F
C. Total	569	102359.79		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Sex	1	1	185.0295	1.2782	0.2587
Species	1	1	443.9876	3.0672	0.0804
Species*Sex	1	1	0.1925	0.0013	0.9709
Distance	1	1	1840.2979	12.7133	0.0004*
Zone	2	2	23.1712	0.0800	0.9231
Species*Zone	2	2	1107.9853	3.8271	0.0223*

Effect Details

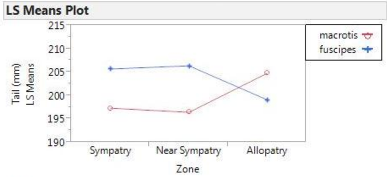
Distance

Species*Zone

Least Squares Means Table

Level	Least Sq Mean	Std Error
macrotis,Sympatry	197.33330	1.5452938
macrotis,Near Sympatry	196.44963	0.9911888
macrotis,Allopatry	204.78709	2.9339145
fuscipes,Sympatry	205.69541	1.0573077
fuscipes,Near Sympatry	206.38717	1.4430849
fuscipes,Allopatry	199.10877	3.5548725

LS Means Plot



Contrast

Test Detail

macrotis,Sympatry	0
macrotis,Near Sympatry	0
macrotis,Allopatry	1
fuscipes,Sympatry	0
fuscipes,Near Sympatry	0
fuscipes,Allopatry	-1
Estimate	5.6783
Std Error	6.1358
t Ratio	0.9254
Prob>|t|	0.3551
SS	123.97

SS	NumDF	DenDF	F Ratio	Prob > F
124	1	561	0.8565	0.3551

Contrast

Test Detail

macrotis,Sympatry	1	0
macrotis,Near Sympatry	0	0
macrotis,Allopatry	-1	0
fuscipes,Sympatry	0	1
fuscipes,Near Sympatry	0	0
fuscipes,Allopatry	0	-1
Estimate	-7.454	6.5866
Std Error	3.4905	3.4665
t Ratio	-2.135	1.9001
Prob>|t|	0.0332	0.0579
SS	660.09	522.62

SS	NumDF	DenDF	F Ratio	Prob > F
718.2	2	561	2.4808	0.0846

Contrast

WARNING: Non-Testable Contrast

Test Detail

macrotis,Sympatry	-0.5	0	0
macrotis,Near Sympatry	-0.5	0	0
macrotis,Allopatry	1	0	0
fuscipes,Sympatry	0	-0.5	0
fuscipes,Near Sympatry	0	-0.5	0
fuscipes,Allopatry	0	1	0
Estimate	7.8956	-6.933	0
Std Error	3.1451	3.3029	0
t Ratio	2.5105	-2.099	0
Prob>|t|	0.0123	0.0363	1
SS	912.31	637.69	0

SS	NumDF	DenDF	F Ratio	Prob > F
943.6	2	561	3.2593	0.0391*

APPENDIX C – RAW DATA

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
1	Female	2.465	35		39	200	*macrotis*	n/a	*macrotis*	-2688.36	NSM	35.769745	-120.801318
2	Female	2.482	36	9.02	40	203	*fuscipes*	n/a	*fuscipes*	3115.99	NSF	35.782558	-120.790513
3	Female	2.415	35	8.52	37	179	*macrotis*	n/a	unknown	-24005.15	AM	35.75807	-120.872856
4	Female	2.463	38	8.56	38	197	*macrotis*	n/a	unknown	-25540.57	AM	35.758743	-120.878389
5	Female	2.392	31		38	177	*macrotis*	n/a	*macrotis*	-10967.3	AM	35.753164	-120.820452
6	Female	2.483	35		40	209	*macrotis*	n/a	*macrotis*	-13044.72	AM	35.75184	-120.82845
7	Female	2.352	29		38	163	*macrotis*	n/a	*macrotis*	-1323.45	NSM	35.772058	-120.797671
8	Female	2.450	33			203	*macrotis*	n/a	*macrotis*	-2153.64	NSM	35.770656	-120.799899
9	Female	2.466	32		41	209	*macrotis*	n/a	*macrotis*	-2365.71	NSM	35.770508	-120.800689
10	Female	2.453	31		40	213	*macrotis*	n/a	*macrotis*	-2084.87	NSM	35.770853	-120.799805
11	Female	2.407	33			177	*fuscipes*	n/a	*fuscipes*	545.95	S	35.775884	-120.793494
12	Female	2.398	29		40	182	*macrotis*	n/a	*macrotis*	-298.53	S	35.773838	-120.794502
13	Female	2.512	40	9.92	39	183	*fuscipes*	n/a	*fuscipes*	-35.3	S	35.774657	-120.794671
14	Female	2.434	34			187	*fuscipes*	n/a	*fuscipes*	537.76	S	35.775857	-120.793495
15	Female	2.405	34	8.28	36	193	*macrotis*	n/a	*macrotis*	-241.64	S	35.773995	-120.794611
16	Female	2.444	32		40	197	*fuscipes*	n/a	*fuscipes*	498.5	S	35.775602	-120.793336
17	Female	2.453	29	9.93	39	199	*fuscipes*	n/a	*fuscipes*	-109.03	S	35.774387	-120.794393
18	Female	2.499	35		43	200	*fuscipes*	n/a	*fuscipes*	-463.82	S	35.773509	-120.79523
19	Female	2.434	33		37	204	*macrotis*	n/a	*macrotis*	-327.29	S	35.773758	-120.794549
20	Female	2.471	34		40	205	*macrotis*	n/a	*macrotis*	-351.29	S	35.773696	-120.794659
22	Female	2.492	35		41	210	*fuscipes*	n/a	*fuscipes*	-360.86	S	35.773768	-120.79509
26	Female	2.497	38	8.35	41	223	*fuscipes*	n/a	*fuscipes*	859.54	S	35.776671	-120.79304

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
27	Female	2.596	41	11.2	42	224	*fuscipes*	n/a	*fuscipes*	-202.01	S	35.774756	-120.795222
28	Female	2.536	36		43	232	*fuscipes*	n/a	*fuscipes*	153.5	S	35.774777	-120.794056
29	Female	2.534	35		43	238	*fuscipes*	n/a	*fuscipes*	394.12	S	35.775243	-120.793435
30	Female	2.520	37		44	198	*fuscipes*	n/a	*fuscipes*	1289.54	NSF	35.777721	-120.792371
32	Female	2.501	36		39	227	*fuscipes*	n/a	*fuscipes*	3249.02	NSF	35.782821	-120.790128
33	Male	2.505	36	8.9	37	200	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
34	Male	2.544	34	10.47	37	200	*macrotis*	*macrotis*	*macrotis*	-9423.24	AM	35.755685	-120.816157
35	Male	2.453	35	8.71	36	196	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
36	Female	2.444	37	8.27	37	199	*macrotis*	n/a	unknown	-25540.57	AM	35.758743	-120.878389
37	Male	2.444	37	8.37	41	203	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
38	Male	2.491	34	9.41	38	199	*macrotis*	*macrotis*	*macrotis*	-7884.36	AM	35.758529	-120.812287
39	Female	2.531	37	9.66	41	207	*macrotis*	n/a	*macrotis*	-8217.07	AM	35.758036	-120.813289
40	Male	2.519			40	205	*macrotis*	*macrotis*	*macrotis*	-1503.08	NSM	35.771944	-120.798371
41	Female	2.427	37	9.53	38	199	*macrotis*	n/a	*macrotis*	-2375.69	NSM	35.77027	-120.80048
42	Female	2.442	34	9.18	37	196	*macrotis*	n/a	*macrotis*	-2609	NSM	35.769848	-120.801072
43	Male	2.474	34	8.98	39	199	*macrotis*	*macrotis*	*macrotis*	-2077.95	NSM	35.770719	-120.799622
44	Female	2.423	36	9.09	40	201	*macrotis*	n/a	*macrotis*	-1289.5	NSM	35.772077	-120.79753
45	Female		35	8.47	40	201	*macrotis*	n/a	*macrotis*	-1339.1	NSM	35.772045	-120.79773
46	Male	2.556	37	9.62	37	203	*macrotis*	intermediate	*macrotis*	-2914.91	NSM	35.769126	-120.801656
47	Female	2.556	33		37	199	*macrotis*	n/a	*macrotis*	-2167.86	NSM	35.770798	-120.800117
48	Male	2.476	36	8.22	39	201	*macrotis*	*macrotis*	*macrotis*	-1471.76	NSM	35.771861	-120.798135
49	Male	2.420	34	8.94	37	195	*macrotis*	*macrotis*	*macrotis*	-2133.1	NSM	35.770795	-120.799959

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
50	Male	2.487	34		41	202	*macrotis*	*macrotis*	*macrotis*	-1520.02	NSM	35.771752	-120.798232
51	Male	2.423	35		39	198	*macrotis*	*macrotis*	*macrotis*	-2374.69	NSM	35.770491	-120.800711
52	Female	2.391	37	9.47	37	197	*macrotis*	n/a	*macrotis*	-2019.33	NSM	35.771036	-120.799708
53	Male	2.470	35	8.89	36	196	*macrotis*	*macrotis*	*macrotis*	-1895.85	NSM	35.770998	-120.799099
54	Male	2.585	36	8.94	40	207	*macrotis*	*macrotis*	*macrotis*	-2577.7	NSM	35.769896	-120.800983
55	Female	2.380	36	9.5	36	194	*macrotis*	n/a	*macrotis*	-2621.61	NSM	35.76998	-120.801271
56	Male	2.491	36	9.49	39	202	*macrotis*	*macrotis*	*macrotis*	-2683.38	NSM	35.769761	-120.801313
57	Female	2.407	37	8.7	36	196	*macrotis*	n/a	*macrotis*	-1107.02	NSM	35.772385	-120.797032
58	Male	2.556	34	8.36	34	196	*macrotis*	*macrotis*	*macrotis*	-2034.11	NSM	35.770951	-120.799683
59	Male	2.574	36	9.69	41	208	*macrotis*	*macrotis*	*macrotis*	-2215.68	NSM	35.770502	-120.800009
61	Male	2.556	38	10.65	41	209	*macrotis*	*macrotis*	*macrotis*	-1317.11	NSM	35.772012	-120.797581
62	Male	2.544	41	9.9	41	212	*fuscipes*	*fuscipes*	*fuscipes*	-1392.93	NSM	35.771913	-120.797824
64	Female	2.362	32		38	192	*macrotis*	n/a	*macrotis*	-466.39	S	35.773519	-120.795274
66	Male	2.585	42	9.55	41	215	*fuscipes*	*fuscipes*	*fuscipes*	461.42	S	35.775504	-120.793395
67	Female	2.473	40	9.53	42	209	*fuscipes*	n/a	*fuscipes*	548.94	S	35.775864	-120.793443
68	Male	2.498	38	8	39	204	*fuscipes*	*fuscipes*	*fuscipes*	701.68	S	35.776265	-120.793248
69	Female	2.498	36	8.2	41	204	*macrotis*	n/a	*macrotis*	-269.25	S	35.77392	-120.794476
70	Male	2.498	37	8.25	42	207	*fuscipes*	*fuscipes*	*fuscipes*	118.67	S	35.774946	-120.794367
72	Female	2.452	38	9.36	36	199	*macrotis*	n/a	*macrotis*	169.59	S	35.775005	-120.794172
73	Male	2.452	36	8.28	41	203	*macrotis*	*macrotis*	*macrotis*	-207.09	S	35.774114	-120.79476
75	Female	2.431	38	9.5	37	199	*macrotis*	n/a	*macrotis*	321.22	S	35.775039	-120.793576
76	Female	2.470	35	7.96	37	197	*macrotis*	n/a	*macrotis*	353.17	S	35.775072	-120.793476

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
78	Female	2.473	31		42	200	*macrotis*	n/a	*macrotis*	-559.79	S	35.773344	-120.795534
79	Male	2.556	37	11.5	40	207	*macrotis*	*macrotis*	*macrotis*	-514.55	S	35.773333	-120.795159
80	Male	2.484	36	8.18	39	201	*macrotis*	n/a	*macrotis*	269.63	S	35.774771	-120.793654
81	Male	2.505	36	9.38	37	200	*macrotis*	*macrotis*	*macrotis*	335.33	S	35.775002	-120.793504
82	Female	2.452	39	7.9	36	200	*fuscipes*	n/a	*fuscipes*	572.51	S	35.775798	-120.793224
83	Female	2.538	41	9.5	43	214	*fuscipes*	n/a	*fuscipes*	153.76	S	35.774552	-120.79405
84	Male	2.505	32	8.25	39	198	*macrotis*	*macrotis*	*macrotis*	353.17	S	35.775072	-120.793476
88	Male	2.401	37	9.45	39	200	*macrotis*	*macrotis*	*macrotis*	292.27	S	35.775295	-120.793954
89	Female	2.473	40	9.8	38	204	*fuscipes*	n/a	*fuscipes*	719.92	S	35.77616	-120.792975
90	Female	2.449	38	9.56	39	202	*macrotis*	n/a	*macrotis*	243.44	S	35.774457	-120.793769
92	Female	2.450	38	11.37	40	204	*fuscipes*	n/a	*fuscipes*	1454.18	NSF	35.777858	-120.79162
93	Female	2.470	39	9.84	39	204	*fuscipes*	n/a	*fuscipes*	1003.38	NSF	35.776758	-120.792363
94	Male	2.585	39			212	*fuscipes*	*fuscipes*	*fuscipes*	1221.05	NSF	35.777327	-120.792061
95	Female	2.505	37	10.16	41	206	*fuscipes*	n/a	*fuscipes*	1519.05	NSF	35.778241	-120.79193
96	Female	2.531	37	9.6	35	200	*fuscipes*	n/a	*fuscipes*	1229.4	NSF	35.777349	-120.79205
98	Male	2.407	33	8.98	39	196	*macrotis*	*macrotis*	*macrotis*	2686.09	NSF	35.781256	-120.790502
100	Male	2.512	41	8.92	41	210	*fuscipes*	*fuscipes*	*fuscipes*	1056.38	NSF	35.776898	-120.79229
101	Female	2.459	36	9.89	38	200	*fuscipes*	n/a	*fuscipes*	1651.37	NSF	35.778403	-120.791413
102	Male	2.633	41		44	220	*fuscipes*	*fuscipes*	*fuscipes*	3265.51	NSF	35.782896	-120.7902
103	Male	2.458	39	7.58	42	207	*fuscipes*	*fuscipes*	unknown	20321.93	AF	35.793734	-120.73017
104	Female	2.484	38	8.64	41	206	*fuscipes*	n/a	unknown	20759.21	AF	35.792463	-120.728071
105	Male	2.574	40	9.04	42	213	*fuscipes*	*fuscipes*	unknown	21462.01	AF	35.791133	-120.725086

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
106	Female	2.512	31	9.18	40	199	*fuscipes*	n/a	unknown	21462.01	AF	35.791133	-120.725086
107	Male	2.470	32			197	*macrotis*	*macrotis*	*macrotis*	-10836.68	AM	35.753208	-120.819876
120	Female	2.387	37	8.06	36	165	*macrotis*	n/a	unknown	-25540.57	AM	35.758743	-120.878389
125	Male	2.369	39	7.9	36	170	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
127	Female	2.336	38	7.6	37	172	*macrotis*	n/a	unknown	-25540.57	AM	35.758743	-120.878389
131	Male	2.420	33	8.14	34	175	*macrotis*	*macrotis*	*macrotis*	-9145.19	AM	35.756113	-120.815344
133	Female	2.455	36	7.99	36	175	*macrotis*	n/a	*macrotis*	-12298.71	AM	35.752424	-120.82576
134	Female	2.382	34	8.59	37	175	*macrotis*	n/a	unknown	-24005.15	AM	35.75807	-120.872856
138	Male	2.433	36	8.76	42	177	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
140	Female	2.369	36	7.86	37	178	*macrotis*	n/a	unknown	-25540.57	AM	35.758743	-120.878389
146	Male	2.464	33	8.76	35	180	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
152	Female	2.301	34	8.02	34	184	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
153	Male	2.455	35	9.59	35	184	*macrotis*	*macrotis*	*macrotis*	-12538.61	AM	35.752347	-120.826746
154	Male	2.223	33	7.34	36	184	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
155	Male	2.338	34	9	36	184	*macrotis*	*macrotis*	*macrotis*	-12383.89	AM	35.752658	-120.826386
156	Female	2.303	35	8.95	34	185	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
158	Male	2.403	32	8.75	36	185	*macrotis*	*macrotis*	*macrotis*	-8863.28	AM	35.756695	-120.814717
159	Male	2.365	33	9.66	36	185	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
160	Male	2.449	37	7.61	37	185	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
161	Male	2.461	35	8.91	37	185	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
162	Male	2.444	33	9.25	37	185	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
163	Female	2.398	36	9.59	35	186	*macrotis*	n/a	*macrotis*	-24786.31	AM	35.758812	-120.875797

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
165	Female	2.356	35	8.02	39	186	*macrotis*	n/a	*macrotis*	-12207.59	AM	35.752738	-120.825688
166	Female	2.378	36	8.58	36	187	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
167	Male	2.364	32	8.73	38	187	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
168	Female	2.262	32	9.16	34	188	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
170	Female	2.519	35	8.56	34	189	*macrotis*	n/a	*macrotis*	-8313.67	AM	35.75778	-120.813428
171	Male	2.498	36	9.61	35	189	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
173	Female	2.307	37	7.96	39	189	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
176	Male	2.403	36	9.4	36	190	*macrotis*	*macrotis*	*macrotis*	-12283.79	AM	35.752395	-120.825662
177	Male	2.430	36	8.45	37	190	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
178	Female	2.396	35	9.41	37	190	*macrotis*	n/a	*macrotis*	-12531.52	AM	35.752485	-120.826858
179	Female	2.360	37	7.94	35	191	*macrotis*	n/a	unknown	-24005.15	AM	35.75807	-120.872856
180	Male	2.413	35	8.66	38	191	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
181	Female	2.332	35	8.04	36	192	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
182	Female	2.428	35	8.71	36	192	*macrotis*	n/a	*macrotis*	-12298.71	AM	35.752424	-120.82576
184	Male	2.525	33		42	192	*macrotis*	*macrotis*	*macrotis*	-10909.63	AM	35.753021	-120.819992
185	Male	2.436	37	8.92	37	193	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
186	Male	2.316	37	8	40	193	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
188	Male	2.394	34	9.28	37	195	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
190	Female	2.422	32	8.57	35	196	*macrotis*	n/a	*macrotis*	-8816.69	AM	35.756832	-120.814668
191	Male	2.322	34	8.21	37	196	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
192	Male	2.550	35	8.98	37	196	*macrotis*	*macrotis*	*macrotis*	-8299.66	AM	35.757853	-120.813456
193	Female	2.431	35	8.84	37	197	*macrotis*	n/a	unknown	-7884.36	AM	35.758529	-120.812287

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
194	Male	2.346	36	7.65	38	197	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
195	Male	2.430	34	8.46	38	197	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
196	Female	2.364	36	7.82	37	198	*macrotis*	n/a	unknown	-24005.15	AM	35.75807	-120.872856
197	Male	2.338	37	8.17	37	198	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
198	Female	2.378	33	8.72	37	198	*macrotis*	n/a	unknown	-24005.15	AM	35.75807	-120.872856
199	Male	2.418	39	9.45	37	198	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
200	Male	2.384	37	8.47	38	198	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
201	Female	2.423	35		39	198	*macrotis*	n/a	*macrotis*	-13064.95	AM	35.751915	-120.828614
202	Female	2.378	34	9.68	36	199	*macrotis*	n/a	*macrotis*	-24786.31	AM	35.758812	-120.875797
204	Female	2.438	35	8.9	36	200	*macrotis*	n/a	*macrotis*	-8464.98	AM	35.7575	-120.813808
205	Male	2.464	37	9.6	37	200	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
206	Male	2.433	36	8.82	37	201	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
207	Male	2.326	36	8.01	39	201	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
208	Male	2.465	34	9.14	36	202	*macrotis*	*macrotis*	*macrotis*	-12222.65	AM	35.752582	-120.825589
209	Female	2.498	36	8.66	34	204	*macrotis*	n/a	*macrotis*	-8301.06	AM	35.757901	-120.813527
210	Male	2.322	35	7.56	36	205	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
211	Female	2.420	36	7.84	36	205	*macrotis*	n/a	*macrotis*	-12363.19	AM	35.752239	-120.82585
212	Male	2.380	34	8.7	36	206	*macrotis*	*macrotis*	unknown	-24786.31	AM	35.758812	-120.875797
213	Female	2.380	36	8.43	37	206	*macrotis*	n/a	unknown	-24786.31	AM	35.758812	-120.875797
215	Male	2.415	37	8.09	39	206	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
216	Male	2.473	37	7.81	38	207	*macrotis*	*macrotis*	unknown	-24005.15	AM	35.75807	-120.872856
217	Female	2.447	32		42	208	*macrotis*	n/a	*macrotis*	-10902.91	AM	35.75302	-120.819958

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
218	Male	2.431	33		42	209	*macrotis*	*macrotis*	*macrotis*	-13208.69	AM	35.75178	-120.829104
219	Male	2.430	35	8.72	35	210	*macrotis*	*macrotis*	*macrotis*	-12288.35	AM	35.752764	-120.826074
220	Female	2.447	37	9.09	35	210	*macrotis*	n/a	*macrotis*	-8340.66	AM	35.757725	-120.813489
221	Male	2.470	38	8.42	37	210	*macrotis*	*macrotis*	unknown	-8584.35	AM	35.757219	-120.814027
222	Female	2.444	37	8.81	39	210	*macrotis*	n/a	*macrotis*	-8229.26	AM	35.75801	-120.813315
223	Male	2.439	35	8.26	40	210	*macrotis*	*macrotis*	*macrotis*	-8816.69	AM	35.756832	-120.814668
225	Male	2.525	33	9.28	37	211	*macrotis*	*macrotis*	*macrotis*	-8712.08	AM	35.757032	-120.814414
226	Male	2.505	36	8.28	36	212	*macrotis*	*macrotis*	*macrotis*	-12288.32	AM	35.752473	-120.825766
227	Female	2.491	38	8.35	38	212	*macrotis*	n/a	*macrotis*	-8271.06	AM	35.757813	-120.813259
228	Male	2.431	38	8.11	42	214	*macrotis*	*macrotis*	unknown	-25540.57	AM	35.758743	-120.878389
229	Male	2.455	35		42	214	*macrotis*	*macrotis*	*macrotis*	-13133	AM	35.751875	-120.82887
230	Female	2.396	36	8.03	36	215	*macrotis*	n/a	*macrotis*	-12199.27	AM	35.752538	-120.825437
231	Male	2.364	34	7.96	39	220	*macrotis*	*macrotis*	*macrotis*	-12305.41	AM	35.752383	-120.825746
232	Female	2.531	37	8.73	36	228	*macrotis*	n/a	*macrotis*	-8230.6	AM	35.75802	-120.813335
234	Female	2.431					*macrotis*	n/a	*macrotis*	-13194.72	AM	35.751861	-120.829124
235	Female	2.498					*macrotis*	n/a	*macrotis*	-10852.27	AM	35.753209	-120.819953
237	Male	2.267	31				*macrotis*	*macrotis*	*macrotis*	-13053.34	AM	35.751868	-120.828516
238	Male	2.512	31				*macrotis*	*macrotis*	*macrotis*	-10992.26	AM	35.753148	-120.820552
263	Male	2.505	33		39	160	*macrotis*	*macrotis*	*macrotis*	-1849.31	NSM	35.771136	-120.799045
264	Female	2.362	35		40	160	*macrotis*	n/a	*macrotis*	-2153.64	NSM	35.770656	-120.799899
271	Male	2.553	36		42	165	*macrotis*	*macrotis*	*macrotis*	-1800.59	NSM	35.771224	-120.798921
277	Male	2.362	39	7.97	37	171	*macrotis*	*macrotis*	*macrotis*	-2875.96	NSM	35.769199	-120.80156

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
280	Male	2.332	35	7.91	36	173	*macrotis*	*macrotis*	*macrotis*	-2075.12	NSM	35.770913	-120.799826
281	Male	2.491	35	8.51	37	173	*macrotis*	*macrotis*	*macrotis*	-2235.81	NSM	35.770692	-120.800307
283	Female	2.512	38	9.15	36	174	*macrotis*	n/a	*macrotis*	-2564.47	NSM	35.769899	-120.800926
286	Female	2.446	34	8.8	34	175	*macrotis*	n/a	*macrotis*	-1813.95	NSM	35.771399	-120.799178
291	Female	2.477	35	10.09	36	178	*macrotis*	n/a	*macrotis*	-1842.75	NSM	35.771384	-120.79929
293	Male	2.544	35	9.69	40	178	*macrotis*	*macrotis*	*macrotis*	-2777.93	NSM	35.769615	-120.80158
294	Male		32		43	178	*macrotis*	*macrotis*	*macrotis*	-2083.31	NSM	35.77089	-120.799838
300	Female	2.491	37	8.04	36	181	*macrotis*	n/a	*macrotis*	-2483.6	NSM	35.770075	-120.800754
301	Male	2.531	36	8.51	38	181	*macrotis*	intermediate	*macrotis*	-2527.28	NSM	35.769948	-120.800811
302	Male	2.408	34	8.88	38	181	*macrotis*	*macrotis*	*macrotis*	-2811.06	NSM	35.769556	-120.801665
311	Female	2.418	31		40	182	*macrotis*	n/a	*macrotis*	-1928.27	NSM	35.771014	-120.79927
312	Male	2.462	33		41	182	*macrotis*	n/a	*macrotis*	-2601.23	NSM	35.769811	-120.800995
313	Female	2.470	37	9.17	36	183	*macrotis*	n/a	*macrotis*	-2818.35	NSM	35.769436	-120.801566
314	Female	2.477	35	9.69	37	183	*macrotis*	n/a	*macrotis*	-2150.64	NSM	35.770558	-120.799772
316	Male	2.465	32		41	183	*macrotis*	*macrotis*	*macrotis*	-1897.34	NSM	35.771306	-120.79945
319	Male	2.387	36	7.62	39	184	*macrotis*	*macrotis*	*macrotis*	-2048.55	NSM	35.77094	-120.799736
320	Male	2.556	35	10.33	40	184	*macrotis*	*macrotis*	*macrotis*	-1962.05	NSM	35.77122	-120.799646
321	Male	2.491	40	8	41	184	*macrotis*	*macrotis*	unknown	-2619.37	NSM	35.770027	-120.80131
322	Male	2.553	33		45	184	*macrotis*	*macrotis*	*macrotis*	-1748.91	NSM	35.771496	-120.798991
323	Male	2.265	33		32	185	*macrotis*	*macrotis*	unknown	-1715.74	NSM	35.771384	-120.798713
324	Female	2.442	33	7.9	34	185	*macrotis*	n/a	*macrotis*	-2438.01	NSM	35.77029	-120.800782
325	Female	2.477	35		42	185	*macrotis*	n/a	*macrotis*	-2223.29	NSM	35.770524	-120.800069

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
326	Female	2.373	36	7.84	34	186	*macrotis*	n/a	*macrotis*	-1715.74	NSM	35.771384	-120.798713
329	Female	2.367	36	8.23	38	186	*macrotis*	n/a	*macrotis*	-1746.86	NSM	35.771551	-120.79904
331	Male	2.519	35	9.72	39	187	*macrotis*	*macrotis*	*macrotis*	-1671.38	NSM	35.771622	-120.798779
333	Female	2.491	36	9.86	35	188	*macrotis*	n/a	*macrotis*	-1845.14	NSM	35.771397	-120.799314
334	Male	2.491	34		36	188	*macrotis*	*macrotis*	*macrotis*	-2150.64	NSM	35.770558	-120.799772
336	Male	2.538	37	10.83	38	189	*macrotis*	*macrotis*	*macrotis*	-1724.7	NSM	35.771347	-120.798711
337	Male	2.538	37	10.83	38	189	*macrotis*	*macrotis*	*macrotis*	-1724.7	NSM	35.771347	-120.798711
338	Male	2.394	35	8.19	36	190	*macrotis*	*macrotis*	*macrotis*	-1760	NSM	35.771488	-120.799032
339	Male	2.336	34	8.24	36	190	*macrotis*	*macrotis*	*macrotis*	-2360.39	NSM	35.770285	-120.800427
340	Male	2.470	34	8.73	36	190	*macrotis*	*macrotis*	*macrotis*	-2328.04	NSM	35.770357	-120.80036
341	Female	2.462	37	8.74	36	190	*macrotis*	n/a	*macrotis*	-2844.16	NSM	35.769247	-120.801468
342	Male	2.484	33	9.31	36	190	*macrotis*	*macrotis*	*macrotis*	-2341.54	NSM	35.77024	-120.800289
344	Female	2.375	34		36	190	*macrotis*	n/a	*macrotis*	-2125.37	NSM	35.770626	-120.799734
345	Female	2.418	37	8.25	38	190	*macrotis*	n/a	*macrotis*	-1573.29	NSM	35.771612	-120.798315
347	Female	2.384	35		38	190	*macrotis*	n/a	*macrotis*	-1724.7	NSM	35.771347	-120.798711
348	Female	2.384	35		38	190	*macrotis*	n/a	*macrotis*	-1724.7	NSM	35.771347	-120.798711
349	Female	2.458	34		39	190	*macrotis*	n/a	*macrotis*	-1661.5	NSM	35.771452	-120.798539
353	Male	2.505		7.99	38	191	*macrotis*	*macrotis*	*macrotis*	-2102.91	NSM	35.7709	-120.799936
354	Female	2.425	35	9.4	38	191	*macrotis*	n/a	*macrotis*	-2766.43	NSM	35.769601	-120.801513
356	Female	2.394	36	8.08	35	192	*macrotis*	n/a	*macrotis*	-2511.55	NSM	35.770165	-120.800977
358	Male	2.377	37	7.69	41	192	*macrotis*	*macrotis*	*macrotis*	-2558.42	NSM	35.770037	-120.80105
359	Female	2.450	35		41	192	*macrotis*	n/a	*macrotis*	-1800.51	NSM	35.771243	-120.798943

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
361	Female	2.380	35	8.25	40	193	*macrotis*	n/a	*macrotis*	-1694.89	NSM	35.771621	-120.798883
362	Male	2.455	36	8.7	36	194	*macrotis*	*macrotis*	*macrotis*	-1741.56	NSM	35.771358	-120.798803
363	Female	2.403	35	9.1	36	194	*macrotis*	n/a	*macrotis*	-2356.01	NSM	35.770277	-120.800398
364	Male	2.364	36	9.67	37	194	*macrotis*	*macrotis*	*macrotis*	-2844.81	NSM	35.769209	-120.801426
365	Female	2.401	33	8.94	38	194	*macrotis*	n/a	*macrotis*	-1963.14	NSM	35.771188	-120.799618
366	Male	2.525	37	9.33	39	194	*macrotis*	*macrotis*	*macrotis*	-2123.28	NSM	35.770597	-120.79969
368	Female	2.436	34	9.07	36	195	*macrotis*	n/a	*macrotis*	-2215.68	NSM	35.770502	-120.800009
369	Male	2.340	32	8.07	38	195	*macrotis*	*macrotis*	*macrotis*	-2699.65	NSM	35.769694	-120.801313
370	Male	2.447	35	7.86	39	195	*macrotis*	*macrotis*	*macrotis*	-1554.05	NSM	35.771731	-120.798366
371	Female	2.462	35	7.8	35	196	*macrotis*	n/a	*macrotis*	-2344.27	NSM	35.770448	-120.800532
372	Female	2.512	35	9.62	35	196	*macrotis*	n/a	*macrotis*	-1963.14	NSM	35.771188	-120.799618
373	Female	2.418	36	7.92	36	196	*macrotis*	n/a	*macrotis*	-1523.05	NSM	35.771762	-120.798258
374	Female	2.431	35	9.05	37	196	*macrotis*	n/a	*macrotis*	-2745.97	NSM	35.769572	-120.801388
375	Male	2.328	34	8.37	39	196	*macrotis*	*macrotis*	*macrotis*	-2356.01	NSM	35.770277	-120.800398
376	Female		35	7.81	40	196	*macrotis*	n/a	*macrotis*	-1741.56	NSM	35.771358	-120.798803
377	Female	2.307	36	7.93	36	197	*macrotis*	n/a	*macrotis*	-1603.03	NSM	35.771612	-120.798455
378	Male	2.467	34	8.44	37	197	*macrotis*	*macrotis*	*macrotis*	-1717.85	NSM	35.771516	-120.798873
380	Male	2.467	35	8.69	41	197	*macrotis*	*macrotis*	*macrotis*	-1603.03	NSM	35.771612	-120.798455
381	Male	2.574	38	8.87	42	197	*macrotis*	*macrotis*	*macrotis*	-2825.6	NSM	35.76932	-120.801467
383	Female	2.462	35	8.86	38	198	*macrotis*	n/a	*macrotis*	-2880.68	NSM	35.769176	-120.801555
384	Male	2.538	35	9.81	39	198	*macrotis*	*macrotis*	*macrotis*	-2277.46	NSM	35.770415	-120.800194
385	Male	2.362	36		42	198	*macrotis*	*macrotis*	*macrotis*	-2120.74	NSM	35.770635	-120.799723

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
386	Male	2.484	37	8.15	36	199	*macrotis*	*macrotis*	*macrotis*	-1724.7	NSM	35.771347	-120.798711
387	Male	2.484	37	8.15	36	199	*macrotis*	*macrotis*	*macrotis*	-1724.7	NSM	35.771347	-120.798711
388	Female	2.352			39	199	*macrotis*	n/a	*macrotis*	-2688.36	NSM	35.769745	-120.801318
390	Female	2.439	34	9.04	36	200	*macrotis*	n/a	*macrotis*	-2280.54	NSM	35.770399	-120.80019
391	Male	2.538	37	8.91	40	200	*macrotis*	*macrotis*	*macrotis*	-2277.46	NSM	35.770415	-120.800194
392	Female	2.427	35	8.31	35	201	*macrotis*	n/a	*macrotis*	-1962.05	NSM	35.77122	-120.799646
393	Male	2.394	35	8.14	36	201	*macrotis*	*macrotis*	*macrotis*	-2483.6	NSM	35.770075	-120.800754
394	Female	2.435	34		39	201	*macrotis*	n/a	*macrotis*	-1547.83	NSM	35.771681	-120.798278
396	Male	2.568	35	8.34	40	201	*macrotis*	*macrotis*	*macrotis*	-2564.47	NSM	35.769899	-120.800926
397	Male	2.405	36	9.49	42	201	*macrotis*	*macrotis*	*macrotis*	-2825.13	NSM	35.769248	-120.80138
398	Male	2.365			43	201	*macrotis*	*macrotis*	*macrotis*	-2618.45	NSM	35.769849	-120.801116
399	Female	2.360	37	8.41	41	202	*macrotis*	n/a	*macrotis*	-2800.56	NSM	35.769324	-120.801355
400	Male	2.375	37	8.06	42	202	*macrotis*	*macrotis*	*macrotis*	-2510.76	NSM	35.770197	-120.801007
402	Male	2.550	34	8.88	38	203	*macrotis*	*macrotis*	*macrotis*	-2052.85	NSM	35.771002	-120.799821
403	Female	2.415	38	8.12	37	204	*macrotis*	n/a	*macrotis*	-2875.96	NSM	35.769199	-120.80156
404	Male	2.427	35	9.79	37	204	*macrotis*	*macrotis*	*macrotis*	-2114.33	NSM	35.770911	-120.799998
405	Female	2.431	40		37	204	*macrotis*	n/a	*macrotis*	-2626.92	NSM	35.769767	-120.801063
406	Male	2.544	36	9.31	38	204	*macrotis*	*macrotis*	*macrotis*	-1845.14	NSM	35.771397	-120.799314
409	Male	2.512	35	8.28	38	206	*macrotis*	*macrotis*	*macrotis*	-2858.33	NSM	35.769383	-120.801689
410	Male	2.491	36	9.52	38	206	*macrotis*	*macrotis*	*macrotis*	-2590.52	NSM	35.769986	-120.801139
411	Female	2.433	36	8.74	39	206	*macrotis*	n/a	*macrotis*	-2219.29	NSM	35.77066	-120.8002
412	Male	2.505	37	9.27	40	206	*macrotis*	*macrotis*	*macrotis*	-2360.39	NSM	35.770285	-120.800427

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
413	Female	2.484	36	8.41	41	207	*macrotis*	n/a	*macrotis*	-2825.6	NSM	35.76932	-120.801467
414	Female	2.447	35	8.29	39	209	*macrotis*	n/a	*macrotis*	-2102.91	NSM	35.7709	-120.799936
415	Male	2.505	37	8.5	40	209	*macrotis*	*macrotis*	*macrotis*	-2483.77	NSM	35.770254	-120.800947
416	Female	2.474	37	8.27	41	210	*macrotis*	n/a	*macrotis*	-1657.76	NSM	35.771649	-120.798747
417	Male	2.450	38	8.12	42	210	*macrotis*	*macrotis*	*macrotis*	-1494.77	NSM	35.771797	-120.798167
418	Male	2.484	33		40	212	*macrotis*	*macrotis*	*macrotis*	-2330.04	NSM	35.770331	-120.80034
419	Female	2.544	40	8.7	43	214	*macrotis*	n/a	*macrotis*	-2557.4	NSM	35.769953	-120.800954
421	Female	2.447	35	9.68	36	216	*macrotis*	n/a	*macrotis*	-2075.12	NSM	35.770913	-120.799826
422	Male	2.550	35	9.13	38	216	*macrotis*	*macrotis*	*macrotis*	-2625.26	NSM	35.769804	-120.801097
423	Female	2.491	38	8.53	36	217	*macrotis*	n/a	*macrotis*	-2619.37	NSM	35.770027	-120.80131
424	Male	2.484	36		42	217	*macrotis*	*macrotis*	*macrotis*	-1568.55	NSM	35.771711	-120.79841
426	Male	2.525	33		43	219	*macrotis*	*macrotis*	*macrotis*	-2573.36	NSM	35.769855	-120.800917
427	Female	2.407	36	8.62	37	220	*macrotis*	n/a	*macrotis*	-2077.95	NSM	35.770719	-120.799622
428	Female	2.519	38	8.68	40	220	*macrotis*	n/a	*macrotis*	-1525.5	NSM	35.771686	-120.798178
429	Female	2.423			41	227	*macrotis*	n/a	*macrotis*	-2122.88	NSM	35.770819	-120.799939
430	Female	2.447	31		46	227	*macrotis*	n/a	*macrotis*	-2103.39	NSM	35.770919	-120.799958
431	Male	2.415	34	9.42	37	229	*macrotis*	*macrotis*	*macrotis*	-2344.82	NSM	35.770477	-120.800565
432	Female	2.407	35	8.96	36	230	*macrotis*	n/a	*macrotis*	-1179.82	NSM	35.772309	-120.797293
434	Male	2.556	37	9.37			*macrotis*	n/a	*macrotis*	-1179.82	NSM	35.772309	-120.797293
440	Male						*macrotis*	*macrotis*	*macrotis*	-1752.16	NSM	35.771275	-120.798754
441	Female						*macrotis*	n/a	*macrotis*	-2338.03	NSM	35.770201	-120.800227
442	Male						*macrotis*	n/a	*macrotis*	-1694.89	NSM	35.771621	-120.798883

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
443	Male						*macrotis*	n/a	*macrotis*	-1261.37	NSM	35.772173	-120.797516
449	Female	2.342	31		38	185	*macrotis*	n/a	*macrotis*	-1188.41	NSM	35.77235	-120.797386
450	Male	2.582	35		44	195	*macrotis*	*macrotis*	*macrotis*	-1251.43	NSM	35.772208	-120.797512
452	Female	2.393	36		40	198	*fuscipes*	n/a	*fuscipes*	-1132.18	NSM	35.772373	-120.797142
454	Male	2.494	33		41	200	*macrotis*	*macrotis*	*macrotis*	-1277.64	NSM	35.772118	-120.797525
455	Male	2.538	31		40	208	*macrotis*	*macrotis*	*macrotis*	-1122.82	NSM	35.772399	-120.79713
456	Male	2.375	36	7.52	40	214	*macrotis*	*macrotis*	*macrotis*	-1339.1	NSM	35.772045	-120.79773
458	Female	2.464	35				*fuscipes*	n/a	*fuscipes*	725.9	S	35.776339	-120.793238
459	Female	2.470	38				*fuscipes*	n/a	*fuscipes*	785.41	S	35.776333	-120.792885
460	Female	2.486			41		*macrotis*	n/a	*macrotis*	316.18	S	35.775057	-120.793606
569	Female	2.362	32		41	168	*macrotis*	n/a	*macrotis*	-608.72	S	35.773284	-120.795723
576	Female	2.380	33		40	171	*fuscipes*	n/a	*fuscipes*	352.32	S	35.775468	-120.793904
579	Female	2.513	33		37	172	*fuscipes*	n/a	*fuscipes*	436.47	S	35.775442	-120.79344
591	Male	2.585	37		44	174	*fuscipes*	*fuscipes*	*fuscipes*	-463.31	S	35.77349	-120.795175
594	Female	2.439	37	8.93	37	175	*fuscipes*	n/a	*fuscipes*	839.69	S	35.776615	-120.793056
596	Female	2.324	35	8.1	36	176	*macrotis*	n/a	*macrotis*	261.14	S	35.774695	-120.793673
620	Female	2.461	39	10.28	40	180	*fuscipes*	n/a	*fuscipes*	338.24	S	35.775382	-120.793839
626	Male	2.412	31		41	181	*macrotis*	*macrotis*	*macrotis*	-318.41	S	35.773904	-120.795098
628	Female	2.394	33		35	182	*macrotis*	n/a	*macrotis*	-370.3	S	35.773679	-120.794895
641	Male	2.415	36	9.88	38	183	*macrotis*	*macrotis*	*macrotis*	407.29	S	35.775273	-120.793406
643	Female	2.484	37	9.75	40	183	*fuscipes*	n/a	*fuscipes*	843.42	S	35.776397	-120.792675
649	Male	2.310	35	7.85	40	184	*macrotis*	*macrotis*	*macrotis*	277.26	S	35.77474	-120.793623

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
651	Male	2.534	35		42	184	*fuscipes*	*fuscipes*	*fuscipes*	-497.53	S	35.773429	-120.795288
659	Female	2.447	38	8.3	37	187	*macrotis*	n/a	*macrotis*	-257.59	S	35.774101	-120.794015
670	Female	2.408	35	9.58	34	190	*macrotis*	n/a	*macrotis*	-291.62	S	35.774719	-120.795532
672	Female	2.431	36	9.6	38	190	*fuscipes*	n/a	*fuscipes*	584.35	S	35.775888	-120.793288
677	Male	2.582	36		41	190	*fuscipes*	*fuscipes*	*fuscipes*	-557.81	S	35.773277	-120.795369
679	Male	2.377	35		41	191	*macrotis*	*macrotis*	*macrotis*	-288.46	S	35.773866	-120.794495
680	Female	2.449	35		36	192	*macrotis*	n/a	*macrotis*	-514.55	S	35.773333	-120.795159
682	Female	2.423	36		39	192	*fuscipes*	n/a	*fuscipes*	644.97	S	35.775963	-120.793083
684	Male	2.538	33		41	192	*fuscipes*	*fuscipes*	*fuscipes*	461.5	S	35.775559	-120.793459
685	Male	2.559	36		41	192	*fuscipes*	*fuscipes*	*fuscipes*	500.95	S	35.775583	-120.793303
686	Male	2.418	39		43	192	*fuscipes*	*fuscipes*	*fuscipes*	506.12	S	35.775927	-120.793858
687	Male	2.569	37		44	192	*fuscipes*	*fuscipes*	*fuscipes*	513.73	S	35.775776	-120.793497
688	Female	2.428	32	9.72	34	193	*macrotis*	n/a	*macrotis*	-296.07	S	35.773944	-120.795032
690	Male	2.375	36	9.14	37	193	*macrotis*	*macrotis*	*macrotis*	-367.89	S	35.773737	-120.795065
691	Male	2.407	39	8.24	38	193	*fuscipes*	*fuscipes*	*fuscipes*	606.01	S	35.775888	-120.793177
692	Female	2.387	36	9.11	38	193	*fuscipes*	n/a	*fuscipes*	-206.96	S	35.774224	-120.7941
696	Female	2.433	30		39	193	*macrotis*	n/a	*macrotis*	447.76	S	35.775404	-120.793353
697	Female	2.418	31		39	193	*fuscipes*	n/a	*fuscipes*	888.96	S	35.776563	-120.792679
699	Male	2.320	30		40	193	*macrotis*	*macrotis*	*macrotis*	-256.09	S	35.774008	-120.794885
700	Female	2.465	35		40	193	*fuscipes*	n/a	*fuscipes*	674.12	S	35.776029	-120.793026
702	Male	2.394	36	8.41	41	193	*macrotis*	*macrotis*	*macrotis*	-301.85	S	35.773863	-120.794845
703	Male	2.501	38		41	193	*macrotis*	*macrotis*	*macrotis*	-256.92	S	35.774074	-120.794064

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
707	Female	2.505	37		35	194	*macrotis*	n/a	*macrotis*	-425.05	S	35.77361	-120.795186
710	Female	2.405	37	9.38	39	194	*fuscipes*	n/a	*fuscipes*	-326.53	S	35.774214	-120.795509
712	Male	2.354	31		39	194	*macrotis*	*macrotis*	*macrotis*	413.81	S	35.77562	-120.793811
714	Female	2.512	39	9.4	40	194	*fuscipes*	n/a	*fuscipes*	749.17	S	35.776241	-120.79294
717	Male	2.408	34	7.99	41	194	*macrotis*	*macrotis*	*macrotis*	-425.05	S	35.77361	-120.795186
724	Male	2.505	38	9.6	37	196	*macrotis*	*macrotis*	*macrotis*	248.08	S	35.77438	-120.793788
728	Female	2.281	36	8.1	42	196	*macrotis*	n/a	*macrotis*	-281.35	S	35.77402	-120.794015
729	Male	2.483	34		43	196	*fuscipes*	*fuscipes*	*fuscipes*	267.23	S	35.775079	-120.793815
730	Female	2.415	37	8.44	37	197	*fuscipes*	n/a	*fuscipes*	859.54	S	35.776671	-120.79304
731	Male	2.531	34	9.02	38	197	*macrotis*	*macrotis*	*macrotis*	-286.83	S	35.774436	-120.79548
732	Female	2.394	40	10.25	38	197	*fuscipes*	n/a	*fuscipes*	163.16	S	35.775103	-120.794498
734	Female	2.369	38	9.54	40	197	*fuscipes*	n/a	*fuscipes*	315.73	S	35.775135	-120.793664
737	Female	2.439	38	9.7	39	198	*fuscipes*	n/a	*fuscipes*	411.81	S	35.775523	-120.793659
738	Male	2.574	40	10.22	39	198	*fuscipes*	*fuscipes*	*fuscipes*	617.62	S	35.776129	-120.793517
741	Male	2.491	38		40	198	*macrotis*	*macrotis*	*macrotis*	-570.36	S	35.773245	-120.795385
744	Male	2.477	40	9.4	43	198	*fuscipes*	n/a	*fuscipes*	274.3	S	35.774961	-120.793706
745	Female	2.364	30	8.36	38	199	*macrotis*	n/a	*macrotis*	269.63	S	35.774771	-120.793654
748	Male	2.593	35		43	199	*fuscipes*	*fuscipes*	*fuscipes*	-281.41	S	35.773885	-120.7946
750	Female	2.505	40	8.4	39	200	*fuscipes*	n/a	*fuscipes*	-225.16	S	35.774263	-120.793967
751	Male	2.538	40	9.94	40	200	*macrotis*	*macrotis*	*macrotis*	-123.29	S	35.774337	-120.794688
752	Female	2.456	33		40	200	*fuscipes*	n/a	*fuscipes*	247.11	S	35.774825	-120.793745
756	Male	2.505	40	8.18	41	201	*macrotis*	*macrotis*	unknown	-286.83	S	35.774436	-120.79548

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
758	Male	2.468	33		44	201	*macrotis*	*macrotis*	*macrotis*	-462.11	S	35.773537	-120.795285
759	Male	2.462	39	9.58	39	202	*macrotis*	*macrotis*	*macrotis*	285.27	S	35.775438	-120.794474
760	Male	2.462	40	9.5	40	202	*fuscipes*	*fuscipes*	*fuscipes*	-143.92	S	35.774447	-120.794141
761	Male	2.568	38	11.2	40	202	*fuscipes*	*fuscipes*	*fuscipes*	275.55	S	35.774787	-120.793637
765	Female	2.420	38	9.53	37	203	*fuscipes*	n/a	*fuscipes*	-12.79	S	35.774631	-120.794581
766	Female	2.470	36	9.62	37	203	*macrotis*	n/a	*macrotis*	-352.34	S	35.773691	-120.794479
767	Female	2.441	36	9.98	37	203	*fuscipes*	n/a	*fuscipes*	-198.89	S	35.774846	-120.795181
768	Female	2.362	37	8.4	38	203	*fuscipes*	n/a	*fuscipes*	195.35	S	35.775054	-120.794995
769	Male	2.550	36	11.35	38	203	*fuscipes*	*fuscipes*	*fuscipes*	338.24	S	35.775382	-120.793839
770	Male	2.505	30	8.21	39	203	*macrotis*	*macrotis*	*macrotis*	-367.89	S	35.773737	-120.795065
771	Male	2.618	40	9.8	40	203	*fuscipes*	*fuscipes*	*fuscipes*	623.71	S	35.775877	-120.793076
774	Male	2.538	37	9.92	41	203	*fuscipes*	*fuscipes*	*fuscipes*	534.29	S	35.775599	-120.793171
775	Female	2.486	33		42	203	*fuscipes*	n/a	*fuscipes*	565.62	S	35.775966	-120.793525
776	Male	2.592	36		44	203	*fuscipes*	*fuscipes*	*fuscipes*	431.98	S	35.775424	-120.793441
777	Female	2.420	37	8.1	37	204	*fuscipes*	n/a	*fuscipes*	532.21	S	35.7757	-120.793295
778	Female	2.377	37	8.35	38	204	*macrotis*	n/a	*macrotis*	-299.79	S	35.773854	-120.794328
779	Female	2.407	35		39	204	*fuscipes*	n/a	*fuscipes*	401.92	S	35.775518	-120.793704
780	Female	2.462	38	10.32	40	204	*fuscipes*	n/a	*fuscipes*	730.49	S	35.776415	-120.793365
781	Male	2.470			40	204	*macrotis*	*macrotis*	*macrotis*	-351.66	S	35.773698	-120.794694
782	Male	2.505	35	8.1	41	204	*macrotis*	*macrotis*	*macrotis*	-309.31	S	35.773823	-120.794353
783	Male	2.580	40	9.52	41	204	*fuscipes*	*fuscipes*	*fuscipes*	277.26	S	35.77474	-120.793623
784	Male	2.491	40	9.55	41	204	*fuscipes*	*fuscipes*	*fuscipes*	-296.07	S	35.773944	-120.795032

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
786	Male	2.521	35		45	204	*fuscipes*	*fuscipes*	*fuscipes*	622.81	S	35.775914	-120.793128
788	Male	2.525	39	8.42	41	205	*fuscipes*	*fuscipes*	*fuscipes*	153.76	S	35.774552	-120.79405
790	Male	2.423	37	9.63	41	205	*macrotis*	*macrotis*	*macrotis*	-257.59	S	35.774101	-120.794015
791	Male	2.597	40	10.16	41	205	*fuscipes*	*fuscipes*	*fuscipes*	-286.83	S	35.774436	-120.79548
792	Female	2.410	33			206	*fuscipes*	n/a	*fuscipes*	525.67	S	35.775934	-120.793725
794	Female	2.393	39	9.7	39	206	*fuscipes*	n/a	*fuscipes*	590.22	S	35.776146	-120.793765
795	Male	2.568	42	9.56	41	206	*fuscipes*	n/a	*fuscipes*	-157.09	S	35.774253	-120.794366
796	Female	2.410	34	7.88	42	206	*macrotis*	n/a	*macrotis*	-157.39	S	35.774301	-120.794853
797	Female	2.477		9.46	40	207	*fuscipes*	n/a	*fuscipes*	-248.91	S	35.774036	-120.794201
798	Female	2.525	37	9.72	41	207	*fuscipes*	n/a	*fuscipes*	661.46	S	35.775987	-120.793033
800	Male	2.606	35		44	207	*fuscipes*	*fuscipes*	*fuscipes*	-360.86	S	35.773768	-120.79509
801	Female	2.428	37	8.3	36	208	*macrotis*	n/a	*macrotis*	-334.35	S	35.773872	-120.795137
802	Male	2.491	35	8.25	37	208	*macrotis*	*macrotis*	*macrotis*	469.06	S	35.775395	-120.793256
803	Male	2.491	35	8.25	37	208	*macrotis*	*macrotis*	*macrotis*	469.06	S	35.775395	-120.793256
804	Male	2.550	36		37	208	*fuscipes*	*fuscipes*	*fuscipes*	779.54	S	35.776298	-120.792864
805	Female	2.484	36	8.93	38	208	*fuscipes*	n/a	*fuscipes*	483.31	S	35.775747	-120.793622
806	Female	2.462	39	9.7	38	208	*fuscipes*	n/a	*fuscipes*	0	S	35.774657	-120.794552
807	Male	2.455	38	10.5	38	208	*fuscipes*	*fuscipes*	*fuscipes*	113.56	S	35.774934	-120.794728
809	Male	2.538	41	9.88	40	208	*fuscipes*	*fuscipes*	*fuscipes*	658.91	S	35.776048	-120.793131
810	Female	2.539	39		41	208	*fuscipes*	n/a	*fuscipes*	324.57	S	35.775102	-120.793604
811	Female	2.512	38	8.25	42	208	*fuscipes*	n/a	*fuscipes*	672.79	S	35.776263	-120.79343
813	Female	2.471	32		42	208	*fuscipes*	n/a	*fuscipes*	248.87	S	35.77508	-120.793893

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
814	Male	2.538	39	8.28	43	208	*macrotis*	*macrotis*	*macrotis*	-300.6	S	35.773854	-120.794788
815	Male	2.618	39	10.16	43	208	*fuscipes*	*fuscipes*	*fuscipes*	719.92	S	35.77616	-120.792975
816	Female	2.417	36		43	208	*fuscipes*	n/a	*fuscipes*	535.48	S	35.77583	-120.793463
817	Female	2.425	32		41	209	*fuscipes*	n/a	*fuscipes*	670.91	S	35.776281	-120.793483
818	Male	2.550	39	9.86	44	209	*fuscipes*	*fuscipes*	*fuscipes*	128.42	S	35.774724	-120.794127
819	Female	2.433	35			210	*fuscipes*	n/a	*fuscipes*	-316.91	S	35.773798	-120.794725
820	Female	2.367	33	8.88	37	210	*macrotis*	n/a	*macrotis*	185.51	S	35.774861	-120.793979
821	Female	2.470	38	8.25	38	210	*fuscipes*	n/a	*fuscipes*	128.42	S	35.774724	-120.794127
822	Female	2.425	36	9.18	39	210	*macrotis*	n/a	*macrotis*	-425.05	S	35.77361	-120.795186
823	Male	2.400	35		42	210	*fuscipes*	*macrotis*	*fuscipes*	285.04	S	35.775206	-120.793867
824	Male	2.505	37		42	210	*macrotis*	*macrotis*	*macrotis*	-425.05	S	35.77361	-120.795186
825	Male	2.455	40		42	210	*macrotis*	*macrotis*	*macrotis*	299.74	S	35.774749	-120.793548
826	Male	2.597	40	9.58	43	210	*fuscipes*	*fuscipes*	*fuscipes*	-89.37	S	35.774448	-120.79471
827	Male	2.648	39	9.92	43	210	*fuscipes*	*fuscipes*	*fuscipes*	-570.36	S	35.773245	-120.795385
828	Male	2.525	37		43	210	*fuscipes*	*fuscipes*	*fuscipes*	-537.05	S	35.773284	-120.795214
829	Female		34		44	210	*fuscipes*	n/a	*fuscipes*	269.66	S	35.774887	-120.793688
830	Male	2.628	38	9.7	45	210	*fuscipes*	*fuscipes*	*fuscipes*	363.23	S	35.775436	-120.793787
831	Female	2.415	34		45	210	*fuscipes*	n/a	*fuscipes*	-300.84	S	35.773863	-120.794833
832	Male	2.597	40	9.6	37	211	*fuscipes*	*fuscipes*	*fuscipes*	586.38	S	35.775999	-120.793459
833	Female	2.512	40	9.58	38	211	*fuscipes*	n/a	*fuscipes*	398.38	S	35.775194	-120.793382
835	Male	2.568	41	9.45	43	211	*fuscipes*	*fuscipes*	*fuscipes*	759.22	S	35.776262	-120.792918
836	Male	2.458	34		45	211	*fuscipes*	*fuscipes*	*fuscipes*	751.9	S	35.776207	-120.792877

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
837	Male	2.470	36	9.38	39	212	*fuscipes*	*fuscipes*	*fuscipes*	-34.19	S	35.774572	-120.794503
838	Male	2.407	40	9.48	40	212	*fuscipes*	*fuscipes*	*fuscipes*	179.15	S	35.775058	-120.794902
839	Female	2.476	37	9.58	40	212	*macrotis*	n/a	*macrotis*	259.09	S	35.774512	-120.793697
840	Female	2.538	40	10.18	40	212	*fuscipes*	n/a	*fuscipes*	338.17	S	35.775154	-120.793589
841	Male	2.607	39		40	212	*fuscipes*	*fuscipes*	*fuscipes*	-244.8	S	35.77405	-120.794907
842	Female	2.423	38	9.6	41	212	*fuscipes*	n/a	*fuscipes*	52.22	S	35.774599	-120.794391
843	Female	2.449	38	9.9	41	212	*fuscipes*	n/a	*fuscipes*	277.73	S	35.775213	-120.793911
844	Female	2.484	38	9.48	43	212	*fuscipes*	n/a	*fuscipes*	130.17	S	35.774678	-120.794114
846	Female	2.484	38		38	213	*fuscipes*	n/a	*fuscipes*	-198.89	S	35.774846	-120.795181
847	Male	2.574	40	10.08	39	213	*fuscipes*	*fuscipes*	*fuscipes*	-229.32	S	35.774068	-120.794278
848	Male	2.544	40	10.09	39	213	*fuscipes*	*fuscipes*	*fuscipes*	-367.04	S	35.773758	-120.795112
849	Female	2.423	38	11.3	39	213	*fuscipes*	n/a	*fuscipes*	113.56	S	35.774934	-120.794728
850	Female	2.484	37	9.7	40	213	*fuscipes*	n/a	*fuscipes*	-326.53	S	35.774214	-120.795509
851	Female	2.473	39	11.24	41	213	*fuscipes*	n/a	*fuscipes*	190.6	S	35.775154	-120.794754
852	Female	2.477	40	9.37	42	213	*fuscipes*	n/a	*fuscipes*	-76.52	S	35.774447	-120.794541
853	Female	2.512	39	9.4	41	214	*fuscipes*	n/a	*fuscipes*	-107.83	S	35.774367	-120.794626
854	Male	2.427	39	8.65	42	214	*fuscipes*	*fuscipes*	*fuscipes*	-76.52	S	35.774447	-120.794541
855	Female	2.449	34		42	214	*fuscipes*	n/a	*fuscipes*	726.59	S	35.776395	-120.793348
856	Female	2.498	39	9.45	43	214	*fuscipes*	n/a	*fuscipes*	207.94	S	35.774835	-120.793886
857	Female	2.484	37	10	39	215	*fuscipes*	n/a	*fuscipes*	-248.81	S	35.77463	-120.79539
858	Male	2.597	38	10.1	41	215	*fuscipes*	*fuscipes*	*fuscipes*	615.18	S	35.776093	-120.793459
859	Male	2.563			42	215	*fuscipes*	*fuscipes*	*fuscipes*	609.7	S	35.776101	-120.793511

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
860	Male	2.600	38		42	215	*fuscipes*	*fuscipes*	*fuscipes*	819.34	S	35.776543	-120.793045
861	Male	2.653	42	10.05	44	215	*fuscipes*	*fuscipes*	*fuscipes*	45.46	S	35.774719	-120.794419
866	Female	2.484	38		41	218	*fuscipes*	n/a	*fuscipes*	-286.83	S	35.774436	-120.79548
867	Female	2.538	33		42	218	*fuscipes*	n/a	*fuscipes*	-482.06	S	35.773531	-120.795407
868	Male	2.602	40	9.76	43	218	*fuscipes*	*fuscipes*	*fuscipes*	-225.16	S	35.774263	-120.793967
869	Male	2.526	36		42	219	*fuscipes*	*fuscipes*	*fuscipes*	273.03	S	35.774347	-120.793714
870	Female	2.471	38	8.96	39	220	*fuscipes*	n/a	*fuscipes*	-92.52	S	35.774445	-120.794724
871	Female	2.538	36	9.54	42	220	*fuscipes*	n/a	*fuscipes*	735.93	S	35.776368	-120.793231
872	Female	2.427	35		42	220	*fuscipes*	n/a	*fuscipes*	-97.3	S	35.774438	-120.79474
873	Male	2.602			43	220	*fuscipes*	*fuscipes*	*fuscipes*	819.34	S	35.776543	-120.793045
874	Male	2.568	36		43	220	*fuscipes*	*fuscipes*	*fuscipes*	-304.72	S	35.773883	-120.794943
875	Male	2.531	38		45	220	*fuscipes*	*fuscipes*	*fuscipes*	373.27	S	35.775447	-120.79375
876	Female	2.423	39		41	221	*fuscipes*	n/a	*fuscipes*	234.38	S	35.774972	-120.793863
877	Male	2.484	35		41	222	*macrotis*	*macrotis*	*macrotis*	450.99	S	35.77544	-120.793374
878	Male	2.538	37		43	222	*fuscipes*	*fuscipes*	*fuscipes*	228.71	S	35.774972	-120.793885
879	Male	2.607	39	11.26	42	223	*fuscipes*	*fuscipes*	*fuscipes*	736.31	S	35.776451	-120.793406
880	Male	2.562	40	10	43	223	*fuscipes*	*fuscipes*	*fuscipes*	195.35	S	35.775157	-120.794791
881	Female	2.531	40	9.78	38	224	*fuscipes*	n/a	*fuscipes*	121.05	S	35.77451	-120.794186
883	Female	2.477	39	7.95	43	225	*fuscipes*	n/a	*fuscipes*	217.16	S	35.775204	-120.794844
884	Male	2.544	41	11.26	43	226	*fuscipes*	*fuscipes*	*fuscipes*	263.18	S	35.775217	-120.793991
886	Male	2.568	40	9.6	38	230	*fuscipes*	*macrotis*	*fuscipes*	-257.14	S	35.774063	-120.794083
887	Male	2.607	41		41	230	*fuscipes*	*fuscipes*	*fuscipes*	162.77	S	35.775027	-120.79486

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
889	Male	2.603	38		45	230	*fuscipes*	*fuscipes*	*fuscipes*	852.22	S	35.776363	-120.792585
905	Male	2.427					*fuscipes*	*fuscipes*	*fuscipes*	-485.56	S	35.773484	-120.795331
906	Male	2.474					*macrotis*	n/a	*macrotis*	-296.07	S	35.773944	-120.795032
912	Female						*macrotis*	n/a	*macrotis*	809.67	S	35.776515	-120.793052
913	Male						*macrotis*	n/a	*macrotis*	330.81	S	35.775374	-120.793867
914	Female						*fuscipes*	n/a	*fuscipes*	-352.34	S	35.773691	-120.794479
915	Male						*fuscipes*	n/a	*fuscipes*	277.26	S	35.77474	-120.793623
916	Male	2.450	35	9.64	40		*fuscipes*	*fuscipes*	*fuscipes*	2930.92	NSF	35.782042	-120.790618
946	Female	2.393	37	8.3	42	170	*fuscipes*	n/a	*fuscipes*	2626.66	NSF	35.781164	-120.790727
948	Male	2.574	38	10.21	37	174	*fuscipes*	*fuscipes*	*fuscipes*	1218.13	NSF	35.777431	-120.792256
952	Female	2.378	35	8.08	37	176	*macrotis*	n/a	*macrotis*	2804.69	NSF	35.78165	-120.790585
956	Male	2.562	39	9.52	41	180	*fuscipes*	*fuscipes*	*fuscipes*	1483.58	NSF	35.777981	-120.791659
960	Male	2.371	33	9.39	38	183	*fuscipes*	*fuscipes*	*fuscipes*	2590.27	NSF	35.781039	-120.790692
963	Male	2.580	38	9.55	37	185	*fuscipes*	*fuscipes*	*fuscipes*	2924.67	NSF	35.781927	-120.790357
968	Male	2.462	35	9.52	37	188	*fuscipes*	*fuscipes*	*fuscipes*	2626.66	NSF	35.781164	-120.790727
969	Male	2.623	35		42	188	*fuscipes*	*fuscipes*	*fuscipes*	1095.67	NSF	35.777043	-120.792301
971	Female	2.467	36	8.84	36	189	*macrotis*	n/a	*macrotis*	1718.7	NSF	35.778544	-120.791264
976	Female	2.512	39	9.6	41	190	*fuscipes*	n/a	*fuscipes*	1155.06	NSF	35.777145	-120.792136
978	Male	2.367	34	8.51	40	191	*fuscipes*	*fuscipes*	*fuscipes*	2839.75	NSF	35.781735	-120.790529
980	Female	2.422	36	9.73	39	193	*fuscipes*	n/a	*fuscipes*	2938.43	NSF	35.782037	-120.790541
981	Female	2.418	35		39	194	*fuscipes*	n/a	*fuscipes*	2818.82	NSF	35.781689	-120.790575
982	Male	2.389	32		40	194	*macrotis*	*macrotis*	*macrotis*	1187.31	NSF	35.777537	-120.792674

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
983	Male	2.519	38	11.58	41	194	*fuscipes*	*fuscipes*	*fuscipes*	1751.11	NSF	35.77865	-120.791261
985	Female	2.498	37		38	196	*fuscipes*	n/a	*fuscipes*	1386.08	NSF	35.7777	-120.791744
986	Male	2.607	38	9.95	41	197	*fuscipes*	*fuscipes*	*fuscipes*	1250.25	NSF	35.777517	-120.792219
987	Female	2.484	36	9.75	38	198	*fuscipes*	n/a	*fuscipes*	1040.44	NSF	35.776906	-120.792388
989	Female	2.477	37	9.88	39	199	*fuscipes*	n/a	*fuscipes*	1125.72	NSF	35.777064	-120.79217
990	Male	2.505	35	9.68	38	200	*macrotis*	*macrotis*	*macrotis*	1239.44	NSF	35.777392	-120.792064
992	Male	2.467	37	9.15	43	200	*fuscipes*	*fuscipes*	*fuscipes*	2897.28	NSF	35.781911	-120.790535
993	Female	2.447	37	9.52	43	200	*fuscipes*	n/a	*fuscipes*	1049.19	NSF	35.776871	-120.792288
994	Female	2.439	34		42	202	*fuscipes*	n/a	*fuscipes*	1261.21	NSF	35.777416	-120.791981
995	Female	2.525	38	9.8	42	203	*fuscipes*	n/a	*fuscipes*	1093.96	NSF	35.776974	-120.792204
996	Male	2.602	39	10.8	42	203	*fuscipes*	*fuscipes*	*fuscipes*	1145.1	NSF	35.777132	-120.79217
997	Female	2.423	36	8.71	37	204	*fuscipes*	n/a	*fuscipes*	2756.7	NSF	35.781555	-120.790719
998	Male	2.568	35	9.62	36	205	*fuscipes*	*fuscipes*	*fuscipes*	2960.01	NSF	35.7821	-120.790536
999	Female	2.484	31		38	206	*macrotis*	n/a	*macrotis*	3063.92	NSF	35.782362	-120.790397
1000	Male	2.568	36	9.67	41	206	*fuscipes*	*fuscipes*	*fuscipes*	2711.53	NSF	35.781395	-120.790657
1001	Male	2.602	36	9.07	39	207	*fuscipes*	*fuscipes*	*fuscipes*	3035.32	NSF	35.782267	-120.790372
1002	Female	2.439	39	10.05	39	207	*fuscipes*	n/a	*fuscipes*	1454.18	NSF	35.777858	-120.79162
1003	Female	2.544	36		39	207	*fuscipes*	n/a	*fuscipes*	3073.76	NSF	35.782436	-120.790524
1004	Female	2.415			41	207	*fuscipes*	n/a	*fuscipes*	1242.91	NSF	35.777595	-120.792418
1008	Male	2.580	37	10.12	43	208	*fuscipes*	*fuscipes*	*fuscipes*	2711.97	NSF	35.781433	-120.790754
1009	Male	2.556	34		43	208	*fuscipes*	*fuscipes*	*fuscipes*	1017.73	NSF	35.776838	-120.792406
1010	Male	2.484	34		44	208	*fuscipes*	*fuscipes*	*fuscipes*	1234.87	NSF	35.777559	-120.792397

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
1011	Female	2.491	40	8.48	37	209	*fuscipes*	n/a	*fuscipes*	1616.21	NSF	35.778271	-120.791388
1012	Female	2.505	33		38	209	*fuscipes*	n/a	*fuscipes*	2720.44	NSF	35.781414	-120.790636
1013	Female	2.491	37	9.68	38	210	*fuscipes*	n/a	*fuscipes*	3035.32	NSF	35.782267	-120.790372
1015	Female	2.415	38	11.46	38	211	*fuscipes*	n/a	*fuscipes*	1632.93	NSF	35.778303	-120.791346
1016	Male	2.591	39	10.5	39	211	*fuscipes*	*fuscipes*	*fuscipes*	2639.98	NSF	35.781149	-120.790587
1018	Male	2.618	37	10.79	42	211	*fuscipes*	*fuscipes*	*fuscipes*	2573.22	NSF	35.781012	-120.790755
1019	Male	2.538	33	9.65	38	212	*fuscipes*	*fuscipes*	unknown	3018.47	NSF	35.782261	-120.790496
1020	Male	2.585	37	9.8	39	212	*fuscipes*	*fuscipes*	*fuscipes*	2954.4	NSF	35.782096	-120.790572
1022	Female	2.512	36	9.83	37	213	*fuscipes*	n/a	*fuscipes*	2731.72	NSF	35.781434	-120.790599
1023	Male	2.562	38	9.75	41	213	*fuscipes*	*fuscipes*	*fuscipes*	3036.32	NSF	35.782291	-120.79043
1024	Male	2.607	36		45	213	*fuscipes*	*fuscipes*	*fuscipes*	1060.29	NSF	35.776963	-120.792369
1027	Female	2.436	38		39	215	*fuscipes*	n/a	*fuscipes*	3023.98	NSF	35.782269	-120.790472
1028	Female	2.484	37	9.32	40	215	*fuscipes*	n/a	*fuscipes*	2964.06	NSF	35.782081	-120.79045
1029	Female	2.498	32	8.42	38	216	*fuscipes*	n/a	*fuscipes*	2885.74	NSF	35.7819	-120.7906
1030	Male	2.568	38	11.2	42	216	*fuscipes*	*fuscipes*	*fuscipes*	1528.46	NSF	35.778273	-120.791934
1031	Male	2.648	40	9.65	43	216	*fuscipes*	*fuscipes*	*fuscipes*	1291.62	NSF	35.777513	-120.791969
1032	Female	2.525	35			217	*fuscipes*	n/a	*fuscipes*	1286.71	NSF	35.777712	-120.792371
1033	Female	2.477	33	9.8	38	217	*fuscipes*	n/a	*fuscipes*	2897.28	NSF	35.781911	-120.790535
1034	Female	2.420	38	9.7	39	217	*fuscipes*	n/a	*fuscipes*	2590.27	NSF	35.781039	-120.790692
1035	Male	2.591	38	11.44	39	218	*fuscipes*	*fuscipes*	*fuscipes*	1003.38	NSF	35.776758	-120.792363
1036	Male	2.613	39	9.73	42	218	*fuscipes*	*fuscipes*	*fuscipes*	1632.93	NSF	35.778303	-120.791346
1037	Female	2.470	36	7.98	38	219	*fuscipes*	n/a	*fuscipes*	3036.32	NSF	35.782291	-120.79043

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
1038	Male	2.562	37	9.31	38	219	*fuscipes*	*fuscipes*	*fuscipes*	3018.47	NSF	35.782261	-120.790496
1039	Female	2.433	34	9.5	38	219	*fuscipes*	n/a	*fuscipes*	2924.67	NSF	35.781927	-120.790357
1041	Female	2.431	31		39	219	*fuscipes*	n/a	*fuscipes*	2924.67	NSF	35.781927	-120.790357
1042	Female	2.519	35		40	219	*fuscipes*	n/a	*fuscipes*	3063.92	NSF	35.782362	-120.790397
1045	Female	2.550	34	9.21	38	222	*fuscipes*	n/a	*fuscipes*	2930.92	NSF	35.782042	-120.790618
1046	Male	2.585	37	9.64	41	222	*fuscipes*	*fuscipes*	*fuscipes*	2818.82	NSF	35.781689	-120.790575
1047	Female	2.458	37		42	222	*fuscipes*	n/a	*fuscipes*	994.89	NSF	35.777064	-120.792964
1048	Male	2.591	38	10.24	39	223	*fuscipes*	*fuscipes*	*fuscipes*	940.26	NSF	35.776922	-120.793029
1049	Female	2.484	38	8.63	37	224	*fuscipes*	n/a	*fuscipes*	1291.62	NSF	35.777513	-120.791969
1050	Male	2.531	41		41	224	*fuscipes*	*fuscipes*	*fuscipes*	3002.77	NSF	35.782226	-120.79053
1052	Female	2.559	31		39	225	*macrotis*	n/a	*macrotis*	3265.51	NSF	35.782896	-120.7902
1053	Male	2.607	39		41	225	*fuscipes*	*fuscipes*	*fuscipes*	2731.72	NSF	35.781434	-120.790599
1054	Female	2.538	30	8.37	42	225	*fuscipes*	n/a	*fuscipes*	3249.02	NSF	35.782821	-120.790128
1055	Male	2.633	41	11.2	43	226	*fuscipes*	*fuscipes*	*fuscipes*	1386.08	NSF	35.7777	-120.791744
1056	Male	2.550	34		44	228	*fuscipes*	*fuscipes*	*fuscipes*	2924.67	NSF	35.781927	-120.790357
1057	Female	2.525	38	10.15	41	235	*fuscipes*	n/a	*fuscipes*	1539.71	NSF	35.778262	-120.791838
1058	Female	2.373	35		38	236	*fuscipes*	n/a	*fuscipes*	2911.23	NSF	35.781949	-120.790524
1082	Female	2.455					*fuscipes*	n/a	*fuscipes*	2897.28	NSF	35.781911	-120.790535
1083	Female	2.470					*fuscipes*	n/a	*fuscipes*	2618.87	NSF	35.781071	-120.790555
1084	Male	2.477					*macrotis*	*macrotis*	*macrotis*	1483.58	NSF	35.777981	-120.791659
1085	Female	2.484					*macrotis*	n/a	*macrotis*	1749.64	NSF	35.778609	-120.791196
1086	Female	2.491					*fuscipes*	n/a	*fuscipes*	3018.47	NSF	35.782261	-120.790496

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
1087	Female	2.512					*fuscipes*	n/a	*fuscipes*	1120.68	NSF	35.777087	-120.792233
1088	Male	2.512					*fuscipes*	*fuscipes*	*fuscipes*	2573.22	NSF	35.781012	-120.790755
1090	Male	2.538					*fuscipes*	n/a	*fuscipes*	1584.66	NSF	35.7782	-120.791449
1091	Female	2.550					*fuscipes*	n/a	*fuscipes*	957.8	NSF	35.776964	-120.793
1092	Male	2.562					*fuscipes*	*fuscipes*	*fuscipes*	1503.7	NSF	35.778115	-120.79178
1093	Male	2.585					*fuscipes*	*fuscipes*	*fuscipes*	1424.44	NSF	35.777822	-120.791729
1094	Female						*macrotis*	n/a	*macrotis*	1020.27	NSF	35.776882	-120.792461
1118	Male	2.531	38	9.54	40	185	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1122	Male	2.550	36	9.98	38	188	*fuscipes*	*fuscipes*	unknown	21462.01	AF	35.791133	-120.725086
1124	Female	2.398	37	7.33	38	190	*fuscipes*	n/a	unknown	20321.93	AF	35.793734	-120.73017
1134	Male	2.574	39	9.23	37	197	*fuscipes*	*fuscipes*	unknown	20321.93	AF	35.793734	-120.73017
1135	Female	2.391	35		39	197	*fuscipes*	n/a	*fuscipes*	8342.13	AF	35.795369	-120.782522
1137	Female	2.452	36	9.78	41	198	*fuscipes*	n/a	*fuscipes*	9550.29	AF	35.79797	-120.77979
1140	Female	2.521	41	8.4	40	202	*fuscipes*	n/a	*fuscipes*	9981.26	AF	35.799015	-120.779107
1142	Male	2.505	40	8.65	41	202	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1143	Female	2.455	35	8.3	36	203	*fuscipes*	n/a	unknown	21462.01	AF	35.791133	-120.725086
1145	Male	2.568	39	8.72	37	204	*fuscipes*	*fuscipes*	unknown	21462.01	AF	35.791133	-120.725086
1148	Female	2.442	39	8.27	41	204	*fuscipes*	n/a	unknown	20759.21	AF	35.792463	-120.728071
1149	Female	2.505	35		43	204	*fuscipes*	n/a	*fuscipes*	9402.94	AF	35.797641	-120.780091
1150	Male	2.544	38	11.07	39	205	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1151	Female	2.539	37		40	205	*fuscipes*	n/a	*fuscipes*	8253.93	AF	35.79525	-120.782912
1152	Male	2.531	38	10.24	41	205	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
1155	Male	2.602	37	10.64	37	207	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1156	Male	2.512	40	8.32	39	207	*fuscipes*	*fuscipes*	unknown	21462.01	AF	35.791133	-120.725086
1157	Male	2.400	40	8.35	40	207	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1160	Female	2.418	38	9.07	40	209	*fuscipes*	n/a	unknown	21462.01	AF	35.791133	-120.725086
1162	Female	2.550	40	8.21	37	210	*fuscipes*	n/a	unknown	20321.93	AF	35.793734	-120.73017
1163	Female	2.519	39	8.35	39	210	*fuscipes*	n/a	unknown	20321.93	AF	35.793734	-120.73017
1164	Female	2.470	37		43	210	*fuscipes*	n/a	*fuscipes*	9402.94	AF	35.797641	-120.780091
1165	Male	2.634			45	210	*fuscipes*	*fuscipes*	*fuscipes*	8217.06	AF	35.795152	-120.782948
1166	Male	2.505	37	8.38	40	211	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1167	Female	2.512	39	9.25	41	211	*fuscipes*	n/a	unknown	20759.21	AF	35.792463	-120.728071
1168	Female	2.446	38	9.79	39	212	*fuscipes*	n/a	unknown	20759.21	AF	35.792463	-120.728071
1169	Female	2.477			39	212	*fuscipes*	n/a	*fuscipes*	9402.94	AF	35.797641	-120.780091
1171	Female	2.525	38	8.32	36	214	*fuscipes*	n/a	unknown	20321.93	AF	35.793734	-120.73017
1172	Female	2.512	36		36	215	*fuscipes*	n/a	*fuscipes*	9402.94	AF	35.797641	-120.780091
1173	Female	2.491	36	8.97	38	215	*fuscipes*	n/a	unknown	20759.21	AF	35.792463	-120.728071
1174	Male	2.538	40	8.71	41	216	*fuscipes*	*fuscipes*	unknown	21462.01	AF	35.791133	-120.725086
1175	Male	2.393	37	7.87	41	217	*fuscipes*	*fuscipes*	unknown	20321.93	AF	35.793734	-120.73017
1176	Male	2.585	42	9.58	41	217	*fuscipes*	*fuscipes*	*fuscipes*	9609.99	AF	35.798181	-120.779854
1177	Male	2.591	41	8.55	39	218	*fuscipes*	*fuscipes*	unknown	21462.01	AF	35.791133	-120.725086
1178	Male	2.618	38	9.9	39	220	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1179	Female	2.525	39	9.81	42	220	*fuscipes*	n/a	unknown	21462.01	AF	35.791133	-120.725086
1181	Female	2.332	38	8.8	40	222	*fuscipes*	n/a	unknown	21462.01	AF	35.791133	-120.725086

ID	Sex	Weight Log10	Ear (mm)	Rostrum (mm)	Hind Foot (mm)	Tail (mm)	Species	Phallus	Genotype	Distance	Zone Name	Latitude	Longitude
1182	Female	2.467	41	8.01	37	224	*fuscipes*	n/a	unknown	20321.93	AF	35.793734	-120.73017
1183	Male	2.550	39	9.76	38	224	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1184	Female	2.470	38	9.92	43	224	*fuscipes*	n/a	unknown	20759.21	AF	35.792463	-120.728071
1185	Male	2.602	41	7.55	41	226	*fuscipes*	*fuscipes*	unknown	20321.93	AF	35.793734	-120.73017
1186	Male	2.607	41	9.38	41	226	*fuscipes*	*fuscipes*	unknown	20759.21	AF	35.792463	-120.728071
1188	Male	2.623	43	8.68	42	228	*fuscipes*	*fuscipes*	unknown	20321.93	AF	35.793734	-120.73017
1189	Male	2.556	41	8.95	39	232	*fuscipes*	*fuscipes*	unknown	20321.93	AF	35.793734	-120.73017