SISTER SPECIES RANGE OVERLAP ACROSS LATITUDES IN THE NEW WORLD

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

MÜBECCEL ÇİSEL KEMAHLI AYTEKİN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
BIOLOGICAL SCIENCES

JANUARY 2017

Approval of the thesis:

SISTER SPECIES RANGE OVERLAP ACROSS LATITUDES IN THE NEW WORLD

submitted by **MÜBECCEL ÇİSEL KEMAHLI AYTEKİN** in partial fulfillment of the requirements for the degree of **Master of Science in Biology Department, Middle East Technical University** by,

Prof. Dr. Gülbin Dural Ünver
Dean, Graduate School of **Natural and Applied Sciences** ______________

Prof. Dr. Orhan Adalı
Head of Department, **Biological Sciences** ______________

Assist. Prof. Dr. Ayşegül Ceren Birand Özsoy
Supervisor, **Biological Sciences Dept., METU** ______________

Examining Committee Members:

Assoc. Prof. Dr. C. Can Bilgin
Biological Sciences Dept., METU ______________

Assist. Prof. Dr. Ayşegül Ceren Birand Özsoy
Biological Sciences Dept., METU ______________

Prof. Dr. Meryem Beklioğlu
Biological Sciences Dept., METU ______________

Assoc. Prof. Dr. Mehmet Somel
Biological Sciences Dept., METU ______________

Assoc. Prof. Dr. Hakan Gür
Biology Dept., Ahi Evran University ______________

Date: **31/01/2017**

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: MÜBECCEL ÇİSEL KEMAHLI AYTEKİN

Signature :

ABSTRACT

SISTER SPECIES RANGE OVERLAP ACROSS LATITUDES IN THE NEW WORLD

Kemahlı Aytekin, Mübeccel Çisel
M.S., Department of Biological Sciences
Supervisor : Assist. Prof. Dr. Ayşegül Ceren Birand Özsoy

January 2017, 92 pages

Species diversity patterns across latitudinal gradients have been studied for decades. Several hypothesis have been put forward to explain the high diversity in the tropics, one of which is the role of biotic interactions, suggested that biotic interactions are higher at low latitudes than at high latitudes. It has been demonstrated that biotic interactions, such as competition, could set the species range limits. Potentially then, if there is a strong competition, species ranges overlap less. Here, we investigate whether the range overlap ratio of passerine sister pairs in the tropics is different from those in the temperate regions. We found that about half of the tropical sister pairs do not have overlapping ranges, when they do, they overlap in a small proportion of their ranges. On the contrary, most of the temperate pairs have overlapping ranges, that with high overlap ratios. But of course, the range overlap ratio pattern that we observed may be due to the range sizes of species since the range sizes of the tropical species are smaller than the temperate species. Our analyses showed that the pattern that we observed is not due to range sizes, the size of the regions, or the age of sister taxa.

However, the main reason for the pattern observed remains unresolved.

Keywords: Species diversity, biotic interactions, body mass ratio, tropical diversity, competition

ÖZ

YENİ DÜNYADA ENLEM BOYUNCA KARDEŞ TÜRLERİN ÇAKIŞMA ALANLARI

Kemahlı Aytekin, Mübeccel Çisel
Yüksek Lisans, Biyolojik Bilimler Bölümü
Tez Yöneticisi : Yrd. Doç. Dr. Ayşegül Ceren Birand Özsoy

Ocak 2017 , 92 sayfa

Enlemler boyunca değişen tür çeşitliliği örüntüleri yıllarca araştırılmıştır. Tropiklerdeki yüksek çeşitliliği açıklamak için çeşitli hipotezler ileri sürülmüştür, bunlardan biri biyotik etkileşimlerin rolü olup, biyotik etkileşimlerin düşük enlemlerde yüksek enlemlerde olduğundan daha fazla olduğunu önermektedir. Rekabet gibi biyotik etkileşimlerin türlerin sınırlarını belirleyebileceği gösterilmiştir. Potansiyel olarak, eğer güçlü bir rekabet varsa, tür alanları daha az çakışır. Burada, tropik bölgelerdeki kardeş ötücü kuş çiftlerinin alanlarının çakışma oranının, ılıman bölgedeki çiftlerden farklı olup olmadığını araştırıyoruz. Tropikteki kardeş çiftlerin yaklaşık yarısının çakışan alanları olmadığını, çakışanların içinde kardeş çiftlerin çakışma alanları oranın az olduğunu tespit ettik. Tersine, ılıman bölgelerde bulunan kardeş çiftlerin çoğunun alanları çakışmaktadır, ve çakışma oranları yüksektir. Fakat, gözlemlediğimiz alan çakışma oranları, türlerin alanlarına bağlı olabilir çünkü tropikal bölgedeki türlerin alanları ılıman bölgedekilere göre daha azdır. Analizlerimiz, gözlemlediğimiz örüntünün alan boyutlarına, bölgelerin büyüklüğüne veya kardeş taksonların yaşına bağlı olmadığını gösterdi. Ancak, gözlemlenen örüntünün temel nedeni çözümlenememiştir.

Anahtar Kelimeler: Tür çeşitliliği, biyotik etkileşimler, vücut ağırlığı oranı, tropikal çeşitlilik, rekabet

To my wonderful family

ACKNOWLEDGMENTS

I would like to thank my advisor Dr. Ayşegül Birand for her constant support, endless guidance and patience. It was a great honour to work with her. Her guidance have provided me to think like a scientist and to make criticism. With her mentorship, I improve myself in lots of subjects and I get a chance to find my interests.

I thank Assoc. Prof. Dr. Can Bilgin for his special guidance and support since my undergraduate. All my success is due to his advices and great mentorship.

I also would like to thank all my thesis committee members; Prof. Dr. Meryem Beklioğlu, Assoc. Prof. Dr. Mehmet Somel, and Assoc. Prof. Dr. Hakan Gür.

My family also provided invaluable support for this work. My mother Saliha Kemahlı, my father İsmail Kemahlı and my sister Dora Kemahlı have a special place for me. Without their guidance, support, and faith on me, it was not possible to be a ecologist. There is no way to express their encouragements.

And there are a lot of people that supported me throughout my studies. Firstly, I want to thank Ozan Kıratlı for his amazing friendship, his advices and his special support to start my master's. My only lab mate, Nurbahar Usta have supported me in my tough times and thank you for not leave me alone. I also want to thank Arev Pelin Sümer, Oğuzhan Beğik, Onur Özer, Emel Çakmak, Babür Erdem, Mesut Erol, Melis Çolakoglu and my friends in the Somel's lab for their friendships and helps.

Lastly, my special thanks to my love, my husband, my friend, and my new family Erdem Aytekin. He gave meaning to my life.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

Species diversity patterns across latitudinal gradients have long fascinated scientists (Stevens 1989, Willig et al. 2003, Schemske et al. 2009). It is well known that the tropical diversity is higher than temperate diversity (Dobzhansky 1950, Ricklefs 1973, Rohde 1992, Orme et al. 2005). Studies have put forward several mechanisms that could drive the latitudinal diversity gradient.

Accumulation of species is related to high diversification rate, i.e. the difference between speciation and extinction rates in tropics (Fine, 2015). Willig et al. (2003) proposed that high speciation rates and low extinction rates provides shorter generation times, higher mutation rates, and faster physiological processes in the warm climates, and thus higher diversification rates in tropics. Higher tropical diversity and diversification rates may be explained by the time-integrated area hypothesis stating that even tropical and temperate regions are the same ages, tropical biomes are larger than temperate biomes because the temperate regions were smaller due to glaciation, and that they are prone to major climate changes over the past 100 million years (Fine and Ree, 2006). Therefore, there was more time for diversification of species in tropics than higher latitudes.

The other driver for the latitudinal diversity gradient is the phylogenetic niche conservatism (Wiens and Donoghue, 2004). It represents that species inherit niches from their ancestors, and if most of species arose in the tropics, niche conservatism may lead to high species diversity in the tropics (Wiens, 2004). In a study with marine bivalves, it is found that these organisms originated in the tropics and then spread to the temperate regions as well as their tropical existence (Jablonski et al., 2006). Kerkhoff et al. (2014) studied on New World woody angiosperms by comparing phylogenetic diversities, and found that colonization from tropical regions to temperate regions is due to global climate change, and there is more diversity in the tropical regions.

Climatic stability is proposed as another driving factor of latitudinal diversity gradient (Pianca 1966, Fine 2015). Tropical regions are more stable climatically than the temperate regions, thus temperate organisms have to deal with temperature alterations more than tropical organisms (Fine, 2015). The species are more likely to be specialists in tropics, when they are found in climatic stable regions with variable habitats and resources. They have enough time to speciate, and are more prone to parapatric and sympatric speciation (Moritz et al., 2000). Moreover, the extinction rate is lower in climate stable regions than more variable environments (Fine, 2015). If a species is found in climate unstable environment, and if its dispersal ability is low, the species could not escape from climate change and face with extinction. Therefore, the extinction rates in temperate regions are higher than tropical region, which acts as refugia (Fine, 2015).

Ecological opportunity hypothesis, the other driving factor, states that due to diversity of evolutionary accessible resources (e.g. free niches and available food, etc), there is high species diversity in the tropics (Schluter, 2016). Species had more time to utilize ecological niches, which are greater in number in lower latitudes, so this drives latitudinal diversity gradient. Schluter (2016) proposed that recent evolutionary rates are higher in temperate regions, but still the latitudinal gradient persist because more time is available for diversification in the tropics. Higher ecological opportunity speeds the diversification rate in higher latitudes (Schluter, 2016).

1.1 Biotic interactions

The studies on latitudinal diversity gradient generally focused on the role of abiotic factors (e.g. physical barriers, climatic factors, resource availability) as we mentioned above (except for ecological opportunity hypothesis). The other less studied hypothesis about the latitudinal diversity gradient is the role of biotic interactions (e.g. competition, predation, and parasites). It has been acknowledged that biotic interactions are higher at low latitudes than at high latitudes. Schemske et al. (2009) searched the literature about biotic interactions with different indicators (e.g. predation, mutualism, herbivory, etc.), and claimed that 77% of the published research show high levels of biotic interactions at low latitudes. They suggested that biotic interactions contribute to species diversity gradient observed. Pianca (1966) also stated that competition is more dense in tropics because of limited resources and more habitat requirements with respect to high species diversity.

One of the example of biotic interactions is interspecific competition, which plays an important role in determining the limits to the geographic ranges of species (Case and Taper 2000, Price and Kirkpatrick 2009, Price et al. 2014). Price et al. (2014) proposed a theoretical model in which two species compete with each other in different degrees of available resources. In the presence of an environmental gradient, the evolutionary stable range limits are dependent on the role of gene-flow by movement of individuals. When species overlap, competition reduces population densities, and thus species cannot adapt to physical conditions at range limits (Price et al., 2014). Price and Kirkpatrick (2009) also built a theoretical model and found that interspecific competition limits the species ranges. Furthermore, the abundance of resources affect the species distributions. Price et al. (2014) studied with Himalayan songbirds, and found that the ultimate limit on diversification is best explained by the failure of species to expand ranges into new localities, because of competitive interactions; not slow accumulation rate. The reproductive isolation and ecological competition among Himalayan songbirds, limit their range expansion, so slows their speciation rates (Price et al., 2014).

The study on *Peucaea* sparrows provide an evidence that a limiting factor to range expansion might be species' sensitivity to competition (Herrera-Alsina and Villegas-Patraca, 2014). In a similar study, Ferrer et al. (1991) showed that two starling species have expanded their ranges as their habitats changed, and when they come into contact, their range expansion slowed down in the sympatric regions. Bullock et al. (2000) showed that two closely related *Ulex* species cannot coexist because their distributions are dependent, so competition limits their ranges. When studied in large scale, these two *Ulex* seem to co-occur, however, at finer scales they cannot coexist due to competition.

The differences in body sizes of co-occurring species could be another signal for competition. Blackburn et al. (1998) suggested that species have more similar body sizes when they overlap less than expected by chance. Closely-related species with similar body sizes occupy similar niches so they compete for resources, and overlap less. If the mass ratio is less than 1.5, species occur together less frequently than expected, and if the mass ratio is greater than 1.5, species coexist more frequently than expected by chance (Brown, 1973). Bowers and Brown (1982) studied on granivorous desert rodent species, and observed that their geographic ranges overlap less when they have similar body sizes (mass ratio <1.5). Letcher et al. (1994) provided further support, they proposed that the species distributions are related to more on their niche requirements, than on competition by close relative species.

1.2 Hypothesis and Objectives

The competition for resources could prevent the overlapping of the species ranges, especially if species are closely related and share similar resources. Hawkins and Diniz-Filho (2006) remarked that future works can focus on evaluating the influence of biotic interactions by envisaging proper variables to confirm biotic effects. Our study is motivated by this unresolved issue. We hypothesize that species ranges will overlap less in the tropical regions due to increased competition.

In this study, we focus on the sister species range overlap across latitudes to understand biotic interactions. We restricted our analyses to passerines in the New World due to several reasons. First, the New World is a isolated land mass from other land masses, so high proportions of birds (95%) are endemic to the continent (Blackburn and Gaston, 1997). Therefore, latitudinal gradient studies for birds are more convenient in the New World. The distributions of birds are also very well known in the New World. The continent extends across a wide range of latitudes. Moreover, the phylogeny, body size, and habitats of birds in the region are relatively well-known (Blackburn and Gaston, 1997).

We used passerines, which is the most diverse order of birds (Raikow, 1986), because they have specific habitats rather than non-passerines, i.e. birds of prey and water birds. We also used only sister pairs to remove the effects of evolutionary dependence. Moreover, since they diverged recently, they might be more prone to have biological interactions, competition in particular.

Even if the sister species ranges overlap less in the tropics as we expect, there could be several reasons other than increased competition, behind that pattern. Therefore, we also investigate:

(i) the range size distribution of sister pairs based on the expectation that smaller range sizes in a region may lead to less range overlap,

(ii) the interplay between species range sizes and the sizes of the regions,

(iii) ages of sister pairs based on the expectation that the region that have less overlap ratios should have younger sister pairs due to the allopatric speciation.

As a more direct demonstration of competition, we also calculate the body mass ratio of sister pairs based on the expectation that species that have similar body masses should overlap less. Lastly, we also calculate the proportion of shared habitat types of sister pairs to investigate whether the species with high range overlap ratios also overlap at finer habitat scale.

CHAPTER 2

METHODS

2.1 Data

Geographic range maps of birds in the Western Hemisphere were downloaded from Nature Serve (Ridgely et al., 2003). We defined the tropical and temperate regions as regions in between 0-23 degrees and 23-66 degrees latitudes respectively (Dempsey, 2014); and selected species whose range centroids fall between specified latitudes for the northern and the southern hemispheres in ArcMap (ESRI, ArcMap 10.0). Island endemics were excluded from the data set (Hawaii Islands, Falkland Islands, Galapagos Islands, Newfoundland Island, and Caribbean Islands).

We used a global phylogeny of birds from Jetz et al. (2012) to identify sister species pairs, and included them if both the species are found within the latitudes specified above. Since Jetz et al. (2012) built a global phylogeny, we checked whether the sister pairs identified in that study are actually sister pairs identified by other more detailed phylogenetic studies. We found that 70% of Jetz et al. (2012)'s sister pairs are also sister pairs, while 4% of Jetz et al. (2012)'s sister pairs are close relatives in other studies. We could not find the phylogenetic data of the remaining species (species list that includes literature search is available in the Appendix D). Subsequently, we defined species as "tropical", "northern temperate" or "southern temperate" based on their range centroids using R (R Development Core Team, 2010) (With "rgdal" (Bivand et al., 2015) and "maptools" (Bivand and Lewin-Koh, 2015) packages).

2.2 Species ranges

We first determined whether the sister species pairs have overlapping ranges or not. Rosser et al. (2015) defined <0.05 overlap as complete allopatry and >0.95 overlap as complete sympatry. Here, for simplicity we define pairs as sympatric, if they have overlapping ranges; and as allopatric, if they do not have. Then, we projected the range polygons of all the species to World Cylindrical Equal Area in R (R Development Core Team 2010, with "rgeos" (Bivand and Rundel, 2015)) to get areas in terms of km^2, and calculated the range sizes of species. To find range overlap areas of sister pairs, we took the intersection of ranges, and again projected intersection ranges to World Cylindrical Equal Area.

We calculated the range overlap ratios of each sympatric pair as the area occupied simultaneously by both the sister species, divided by the area of the smaller ranged species (Barraclough and Vogler, 2000). The range overlap for the sympatric species pairs ranges from near zero values (very small overlap) to one (complete overlap when the smaller ranged sister species is fully nested within the larger ranged species). By definition, the range overlap value is zero for the allopatric pairs. These analyses were performed by using R (R Development Core Team, 2010) with "rgeos" (Bivand and Rundel, 2015), "rgdal" (Bivand et al., 2015) and "maptools" (Bivand and Lewin-Koh, 2015) packages. We also determined the total land area of the tropical, northern temperate and southern temperate regions in ArcMap (ESRI, ArcMap 10.0).

2.3 The null model

We developed a null model to determine whether the observed proportion of sympatric species in different regions is an artifact of species range sizes and the size of the regions. We assumed that the regions are shaped as squares with their respective land areas calculated as km^2, and species ranges are shaped as circles. The actual range size distributions of species in each region are best approximated the Weibull distribution (Fig. A.1). Therefore, in the null model species range sizes were drawn from a Weibull distribution with parameters fitted for each region (Table 2.1).

We then assigned centroid coordinates for each sister species randomly from an uniform distribution. In order not to allow species ranges to exceed the boundaries of regions, we adjusted the coordinates such that the species range centroid (center of the circle) falls no more closer to the edges than radius, r, except when the species range size is larger than that of the region it is found in. Lastly, we recorded whether the species pair is sympatric or allopatric (i.e. with overlap ranges or not, respectively). Each simulation consists of 100 randomly chosen sister pairs. We carried out 1000 simulations for each region. The model was implemented in R (R Development Core Team, 2010). We also performed each simulation with their actual species numbers in each region, and found similar results, but we will represent the results for 100 randomly chosen sister pairs.

Table 2.1: Weibull distribution parameters. Depending on Weibull distributions for each region, sister species range sizes were drawn randomly with the parameters given below.

Region	shape	scale
Tropical	0.49	1,204,056
Northern temperate	0.89	5,486,686
Southern temperate	1.05	1,595,515

2.4 Ages of sister pairs

We extracted the ages of sister pairs from available time-scaled phylogenetics from twelve different studies by using a diagramming software (Microsoft Visio) to get precise results. We were able to get only the ages of 124 sister pairs. Barker et al. (2015) presented time-scaled phylogeny of New World clade Emberizoidea, based on maximum clade credibility from trees assembled on the species tree backbone. Biogeographical reconstructions and molecular clock calibration of Campylorhynchus were obtained by heuristic maximum likelihood and near-most-parsimonious trees (Barker, 2007). Berv and Prum (2014) represented ultrametric species tree chronogram of Cotingidae family in which the time scale was estimated using lognormal relaxed clocks from five molecular rate calibrations of previous studies. Chronogram of the Neotropical genus *Saltator* based on the concatenated data set obtained from Beast (Chaves et al. 2013, Drummond and Rambaut 2007). Irestedt et al. (2009) estimated the divergence times of Furnariidae under a relaxed clock model that implemented in Beast (Drummond and Rambaut, 2007). Miller et al. (2008) provided the consensus Bayesian phylogenetic tree of lowland *Mionectes* flycatchers that is fitted to an enforced molecular clock. The chronogram tree of Nylander et al. (2008) was obtained fifty percent majority-rule consensus tree of thrush genus *Turdus* and closest relatives. Chronogram of Tyrannidae estimated in PATHd8 (Britton et al., 2006) by using fifty percent consensus tree of *Tyrannida* from the Bayesian analyses (Ohlson et al., 2008). Outlaw et al. (2003) provided the ages of sister *Catharus* lineages in a table, and obtained the ages based on the maximum-likelihood topology, using uncorrected (P) distances. Age estimates of Elaenia speciation events mapped onto the concatenated tree topology (Rheindt et al., 2008). Sánchez-González et al. (2015) represented maximum clade credibility tree and ancestral areas reconstruction for *Atlapetes*. Time-calibrated phylogeny of *Dendrocincla* woodcreepers was obtained by using the relaxed-clock model of Beast topology with estimations for the concatenated Bayesian (Weir and Price, 2011).

2.5 Body mass

In order to study the body mass ratio of sister pairs, we used body masses data from Dunning (2008). In Dunning (2008)'s work, body masses were available as male, female, both species combined, and sex unknown. We used the estimates of male masses when available. We calculated the body mass ratio of each sister pairs as the larger body mass divided by the smaller body mass (Brown, 1973).

2.6 Habitat

Sister species' ranges may overlap, but they may not share habitats. Thus, we looked at the proportion of shared habitat types between sister pairs. Habitat data for each species were taken from BirdLife International (2016). We could not find two species in BirdLife International (2016) (which are *Serpophaga munda* and *Asthenes sclateri*), so we excluded two sister pairs that these species found in. We determined whether the sister pairs share habitats or not. If they do, we calculated the proportion of shared habitat types for each pair. We used the same methodology as range overlap calculation, where we divided the number of habitats occupied simultaneously by both the sister species, by the number of habitats of the species which occupy less number habitats in the pair. For example, species A occupies subtropical/tropical dry forest, subtropical/tropical swamp forest, and subtropical/tropical dry shrubland. Its sister, species B occupies subtropical/tropical swamp forest, and temperate shrubland. These two species share only one habitat, i.e. subtropical/tropical swamp forest. The proportion of shared habitat types in this case will be 0.5.

CHAPTER 3

RESULTS

In the Western Hemisphere, there are 2257 of passerine species located between 66 degrees latitudes in the northern and southern hemispheres. Within these, only 1096 species are sister pairs based on Jetz et al. (2012)'s phylogeny. Based on their range centroids, we defined 833 of them as tropical, and 263 of them as temperate species.

3.1 Range overlaps

Typically, sister pairs are found in the same region; however, in some cases sister pairs are found in different regions. Even more interestingly, in three cases, sister pairs are found in the same region but their overlap centroids fall in a different region (Fig. A.2). We called these pairs "mixed", in which either the sister pairs or their overlap areas are in different regions. Here, we present results with "mixed" pairs excluded. Including them in the analyses do not alter the main patterns observed. Please refer to the figures in the Appendix B for the results where "mixed" pairs are included. The numbers of sister pairs that are allopatric or sympatric in tropical, northern, and southern temperate regions is given in Figure 3.1. The central bulge in Figure 3.1 reflects high species diversity in the tropics; temperate regions are much more depauperate compared to the tropics. It appears that there are more sympatric sister pairs than allopatric pairs.

Replotting the data in Figure 3.1 show that 54% of the tropical pairs, 87% of northern temperate pairs and 85% of southern temperate pairs are sympatric (Fig. 3.2). Within the sympatric tropical species, most of the pairs' range overlap ratios are close to zero (Fig. 3.3a). Most of the pairs in northern temperate region have high range

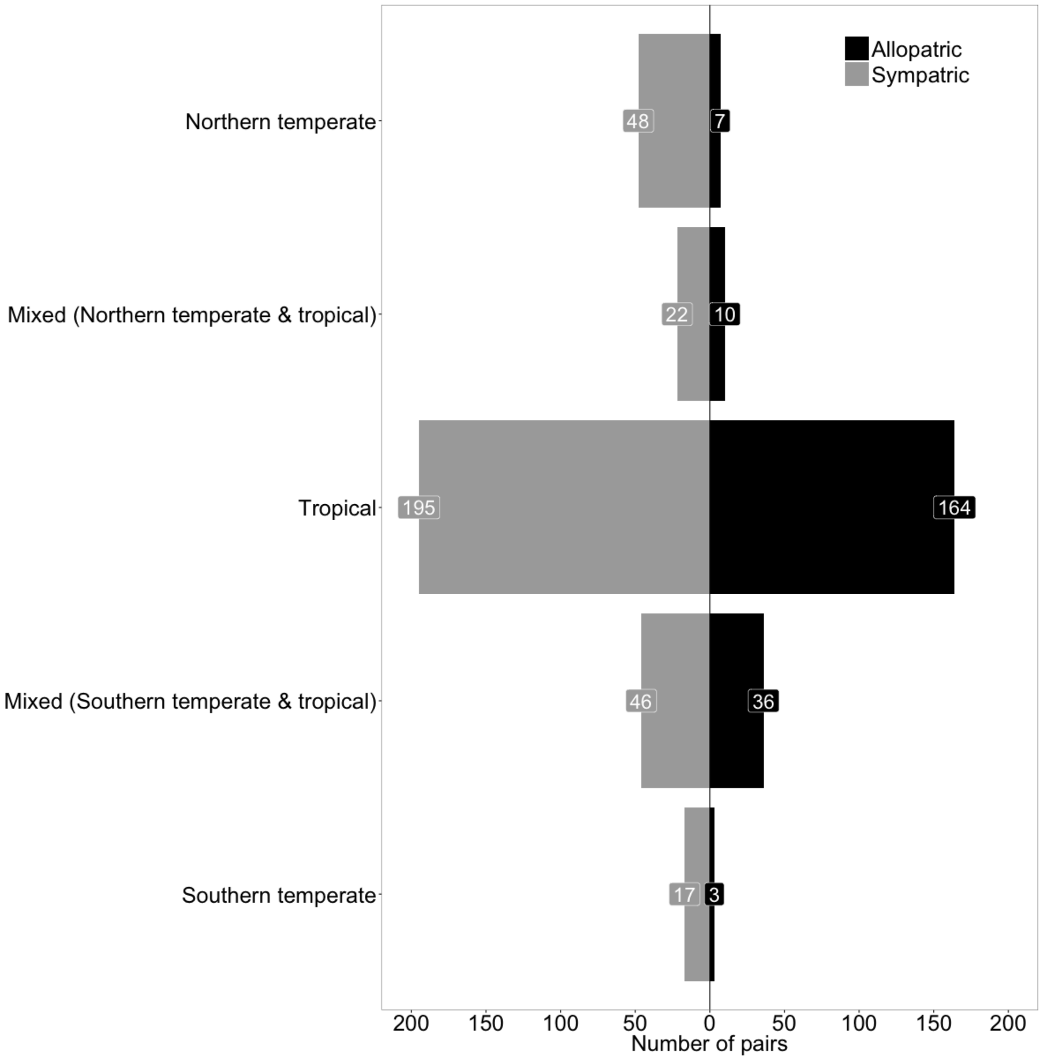


Figure 3.1: The number of sister pairs that are sympatric or allopatric in each region. "Mixed" refers to sister species pairs, whose range centroids are found in different regions, or those who have range centroids in the same region, but, their overlap centroids are located in different regions (i.e., one northern temperate pair overlap in tropics, and two tropical pairs overlap in the southern temperate region; see Figure A.2).

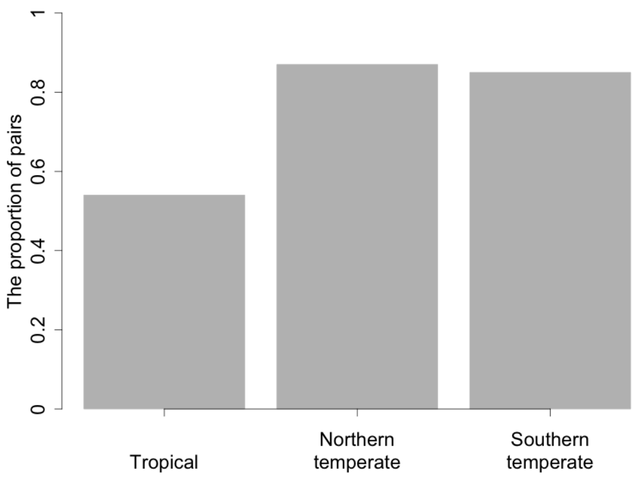


Figure 3.2: The proportion of sister pairs that are sympatric in tropical, northern and southern temperate regions.

overlap ratios (Fig. 3.3b). However, trend is not so obvious in the southern temperate species (Fig. 3.3c). Our results show that about half of the tropical pairs do not have overlapping ranges, and when they do, they overlap in a very small portion of their ranges. On the contrary, most of the northern temperate pairs have overlapping ranges, and that with high overlap ratios. Most of the southern temperate pairs also overlap; however, their overlap ratios could be high or low.

The median range sizes of species in tropical, northern and southern temperate regions are significantly different from each other (Fig. 3.4 and Fig. A.1; Kruskal-Wallis test, p<0.05). Since tropical species have smaller range sizes than the temperate ones, which might be the cause of low range overlap ratios observed, we compared the range overlap ratios in different regions based on their range sizes (Fig. 3.5). Note that the range overlap ratios are calculated as the area occupied simultaneously by both the sister species, divided by the area of the smaller ranged species. Therefore we categorized them based on the small ranged species in the pair. Overlap ratios are still low in the tropics (except for the > 4.10^6 km^2 range size interval), whereas overlap ratios are high in the northern temperate region independent of the range sizes. Species in the southern temperate region does not show any clear trend. Within each range size interval, the median range sizes do not show significant differences in each region (Kruskal-Wallis Test, p>0.05).

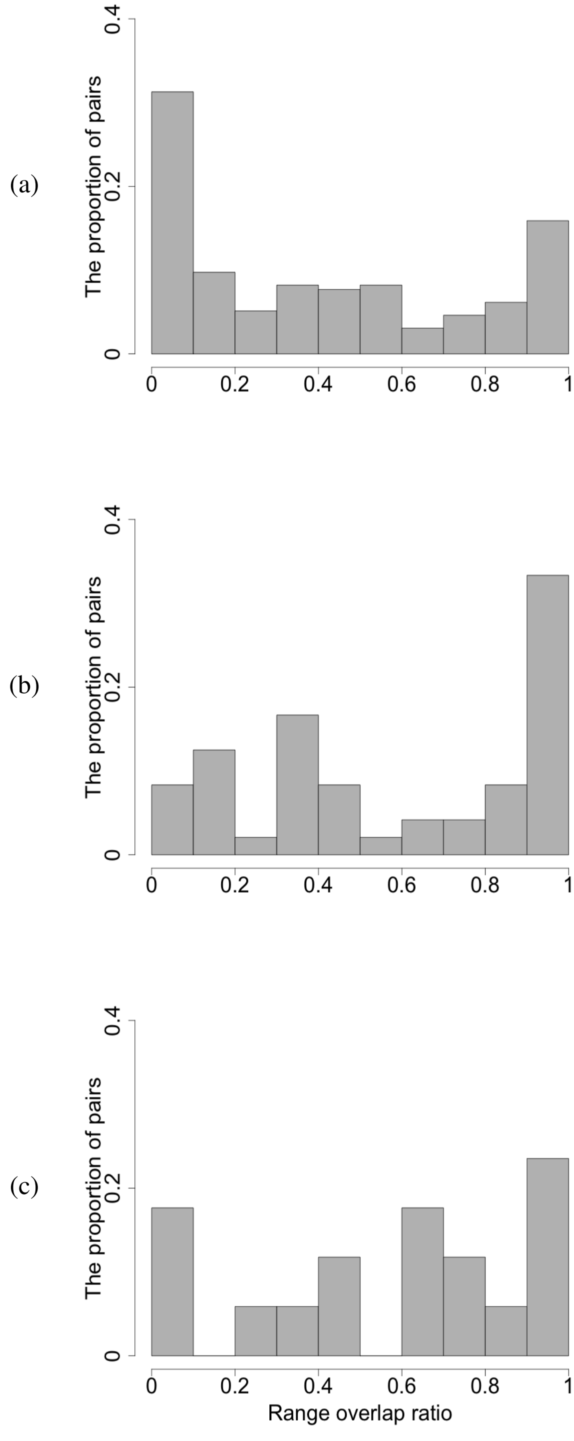


Figure 3.3: The proportion of range overlap ratios of sympatric sister pairs in different regions for (a) tropical, (b) northern and (c) southern temperate regions. The proportion of species were calculated as sympatric pairs' range overlap ratio normalized by the total number of species pairs that are present in each region (P_T=195, P_{NT}=48, P_{ST}=17 respectively). Note that the value zero is not included since it refers to allopatric pairs.

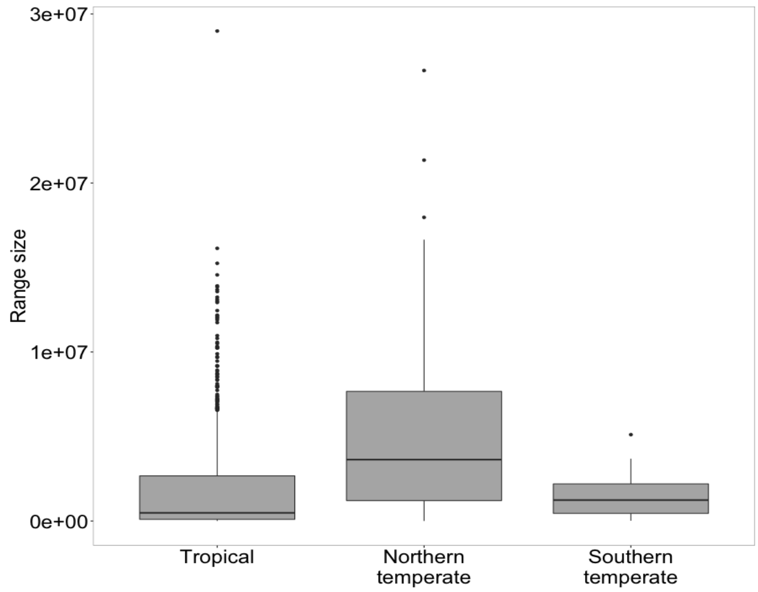


Figure 3.4: Boxplot of range sizes in tropical, northern and southern temperate regions. Median range sizes are 4.9x10^5 km^2, 3.6x10^6 km^2 and 1.2x10^6 km^2, respectively. For each box, the central black line is the median, the edges of the box are 25th and 75th percentiles, the whiskers extend to the most extreme data points (vertical lines above or below the box), and outliers are plotted individually (dots).

Even though the pattern still holds when we control for the range sizes, the method only incorporates the range size of one of the species in the pair. In order to incorporate the effects of the range sizes of each species in the pair, and the potential interaction between species range sizes and the size of the regions, we built a null model that was described in the previous section (see section 2.3). Intriguingly, the observed proportions of sympatric species (starred values in Fig. 3.6; they are out of confidence level) are not within the ranges obtained from the null model, which could suggest that the observed proportion of sympatric pairs is probably not due to the interplay between species range sizes, and the sizes of the regions (tropical region is 15.5 million km^2, northern temperate region is 47.7 million km^2, and southern temperate region is 6.7 million km^2).

3.2 Ages of sister pairs

We plotted the divergence times of the pairs in each region in Figure 3.7. As expected, when species pairs are young, range overlap ratios are lower in each region. Interestingly however, within the youngest sister pairs, the northern temperate pairs have high range overlap ratios. It appears that the observed distributions of range overlap ratios of sister pairs in each region are not related to the ages of pairs, however we are also aware of our data limitation since we have data on 124 pairs only.

3.3 Body mass

The body mass ratios of sympatric and allopatric sister pairs in each region are smaller than 1.5; which means that sister species have similar body sizes (Fig. 3.8; body masses were not available for 44 sister pairs). For allopatric pairs, there is no significant difference between the medians of sister pairs mass ratio in each region (Kruskal-Wallis Test, $p > 0.05$), but for sympatric pairs, at least one sister pair mass ratio is significantly different from other regions (Kruskal-Wallis Test, $p < 0.05$). Figure 3.9 illustrates that there is no correlation between body mass ratios and range overlap ratios of sympatric pairs in each region (Pearson's product-moment correlation, $p > 0.05$ in each region).

3.4 Habitat overlaps

When we look at the relationship between the proportion of share habitat types and range overlap ratio, and found that there is no correlation between the two (Fig. 3.10; Pearson's product-moment correlation, $p > 0.05$ in each region). Indeed, 82% of the tropical, 92% of northern temperate, and 89% of southern temperate sister pairs share habitats (Fig. 3.11), and the proportion of shared habitat types for most of the pairs are close to one (Fig. 3.12). We also checked whether the proportion of pairs shared habitats differ for sympatric and allopatric pairs. Most of the sympatric and allopatric sister pairs share habitats in the tropical and southern temperate regions (Fig. 3.13). Intriguingly, the proportions of sister pairs that share habitats are rather smaller within allopatric sister pairs than sympatric sister pairs in northern temperate region.

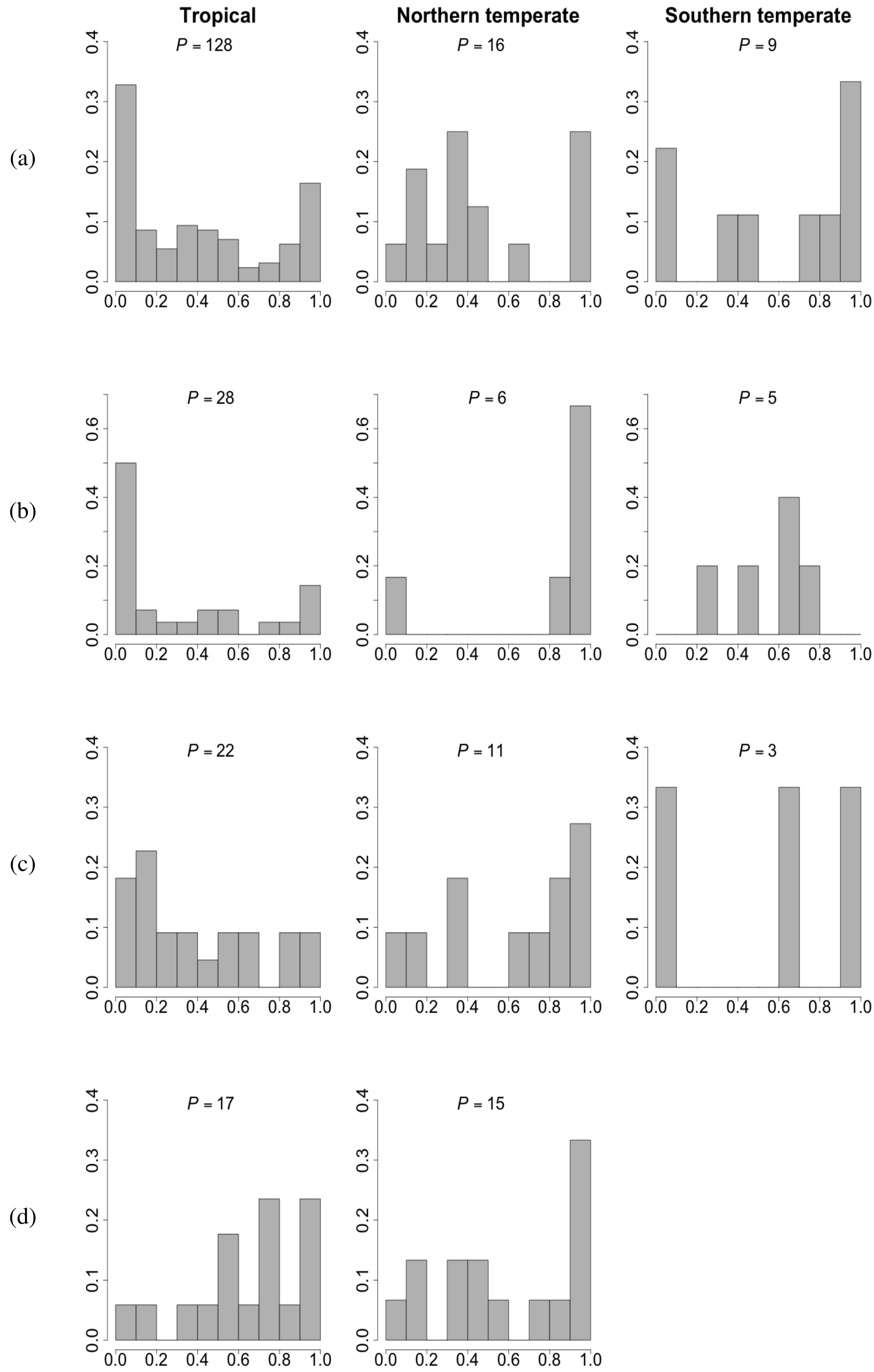


Figure 3.5: The proportion of range overlap ratios in each region. Separated by the range sizes of the smaller species (a) 0–1.10^6 km^2, (b) 1.10^6–2.10^6 km^2, (c) 2.10^6–4.10^6 km^2, and (d) >4.10^6 km^2. The number of pairs in each range interval are given by *P*.

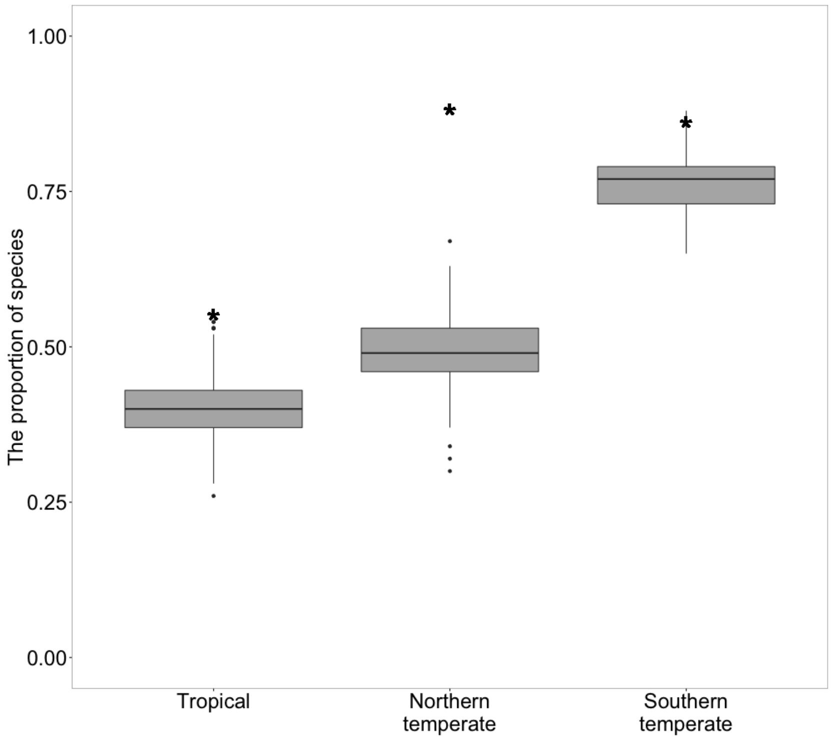


Figure 3.6: Boxplots of the proportion of pairs that are sympatric based on 1000 simulations in each region. Each simulation consists of 100 sister pairs whose range sizes and range centroids are drawn randomly from Weibull and Uniform distributions, respectively. Starred values show the observed proportion of sympatric pairs in Figure 3.2 for each region. Medians are 0.4, 0.49 and 0.77, respectively. For each box, the central black line is the median, the edges of the box are 25th and 75th percentiles, the whiskers extend to the most extreme data points (vertical lines above or below the box), and outliers are plotted individually (dots).

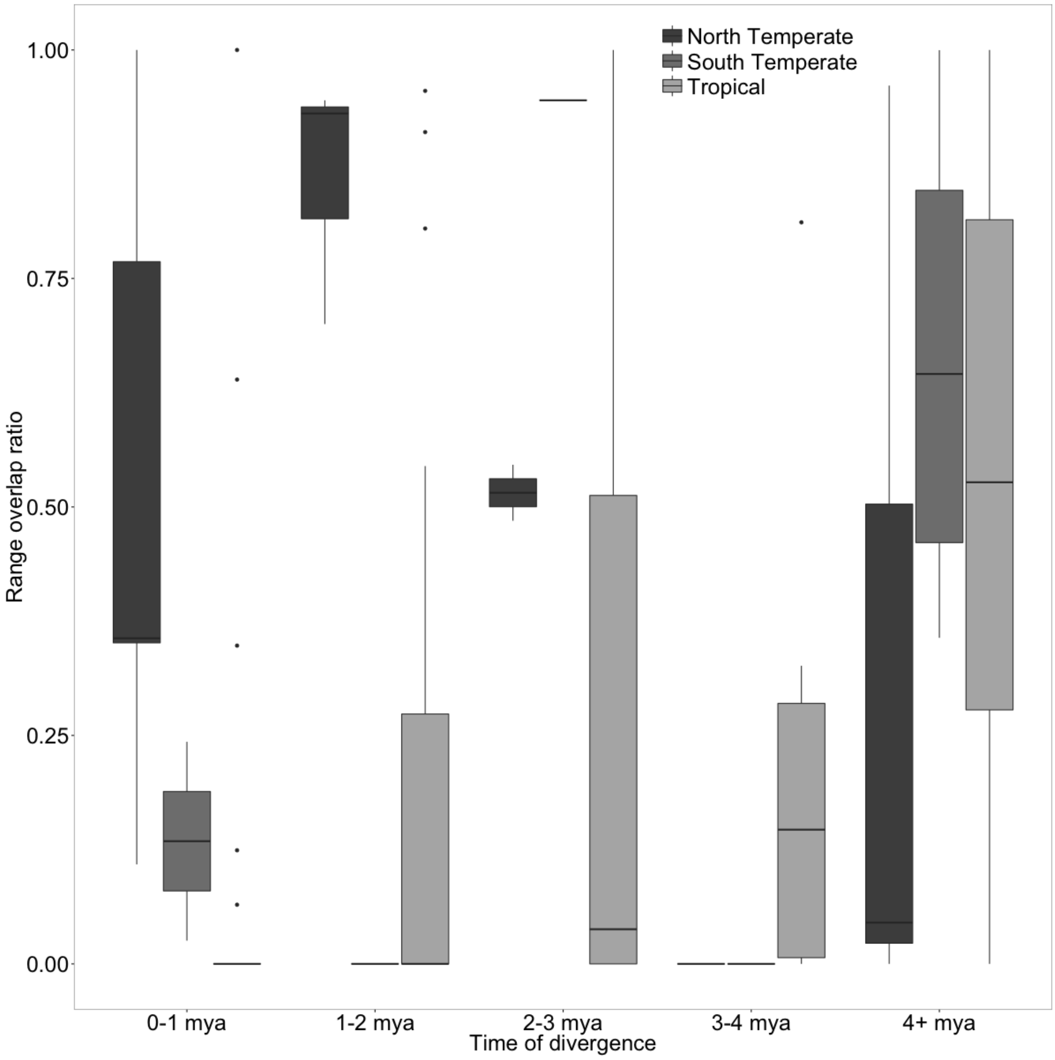


Figure 3.7: Range overlap ratios of sister pairs through time in tropical, northern and southern temperate regions (Total number of sister pairs is 124).

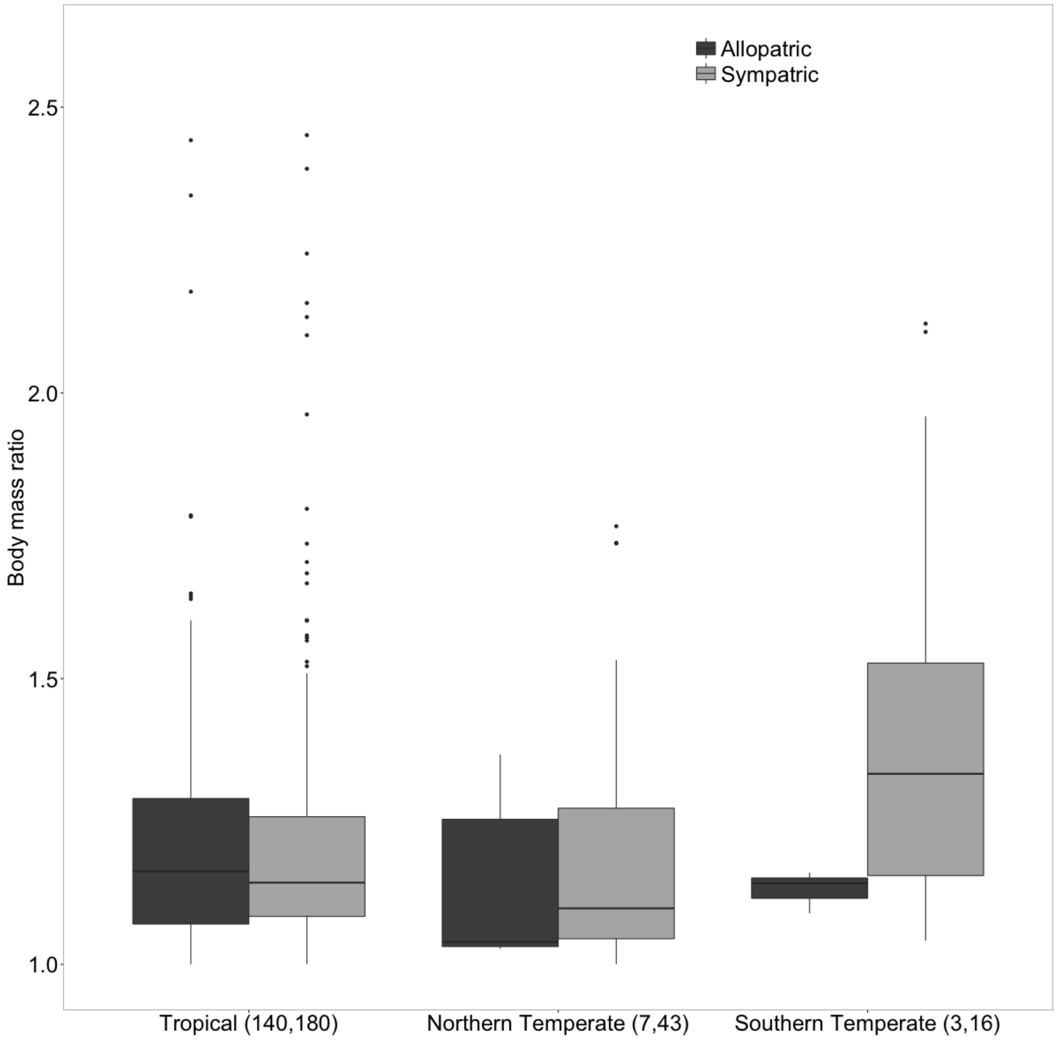


Figure 3.8: Boxplots of body mass ratio of allopatric and sympatric sister pairs in each region. Number of pairs are shown in parenthesis for allopatric and sympatric pairs respectively. Median body mass ratios are 1.16, 1.4, 1.03, 1.09, 1.14 and 1.33, respectively. For each box, the central black line is the median, the edges of the box are 25th and 75th percentiles, the whiskers extend to the most extreme data points (vertical lines above or below the box), and outliers are plotted individually (dots).

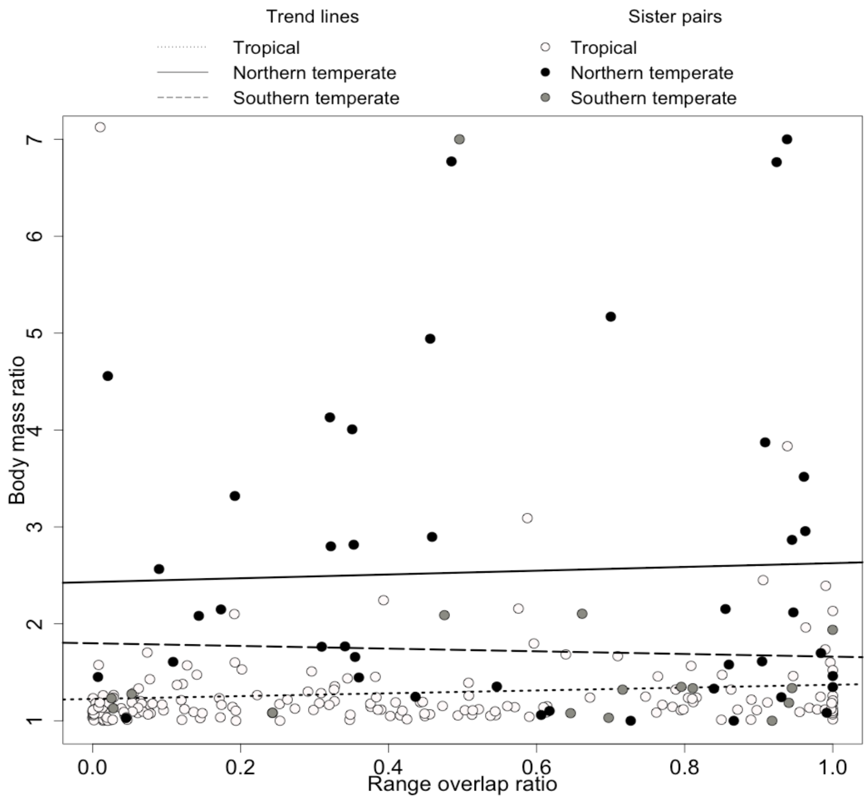


Figure 3.9: The relationship between body mass ratio and range overlap ratio of sister pairs in each region (Pearson's product-moment correlation, p>0.05 in each region). Lines represent the best fits for each region (r^2 vales are 0.008, 0.002, and 0.001, respectively).

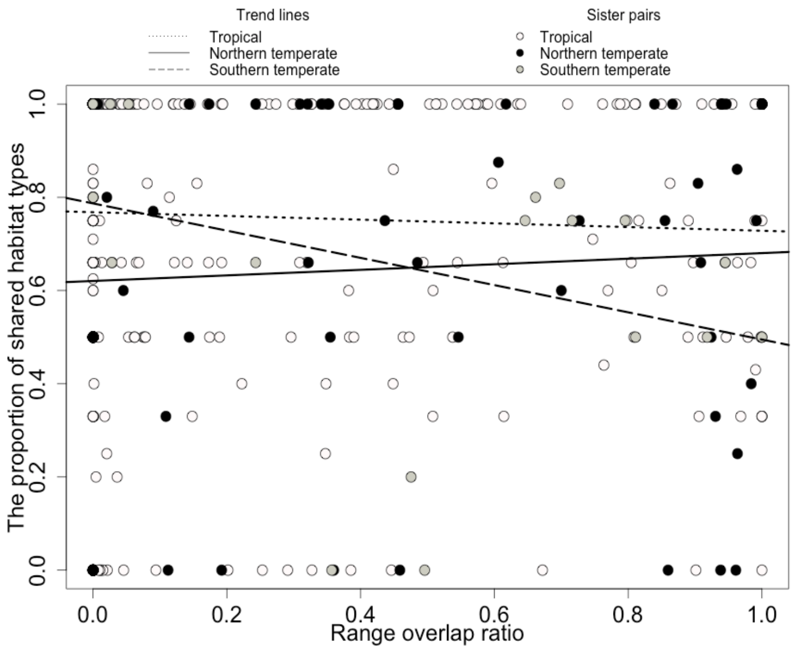


Figure 3.10: The relationship between the proportion of shared habitat types and range overlap ratio of sister pairs in each region (Pearson's product-moment correlation, p>0.05 in each region). Lines represent the best fits for each region (r^2 vales are 0.002, 0.004, and 0.12, respectively).

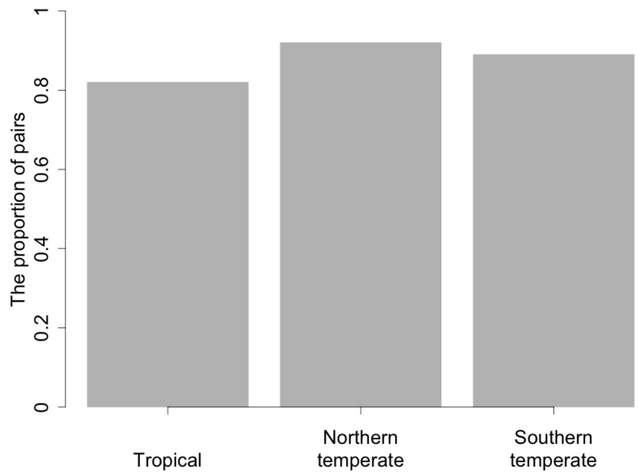


Figure 3.11: The proportion of sister pairs that share habitats in tropical, northern and southern temperate regions.

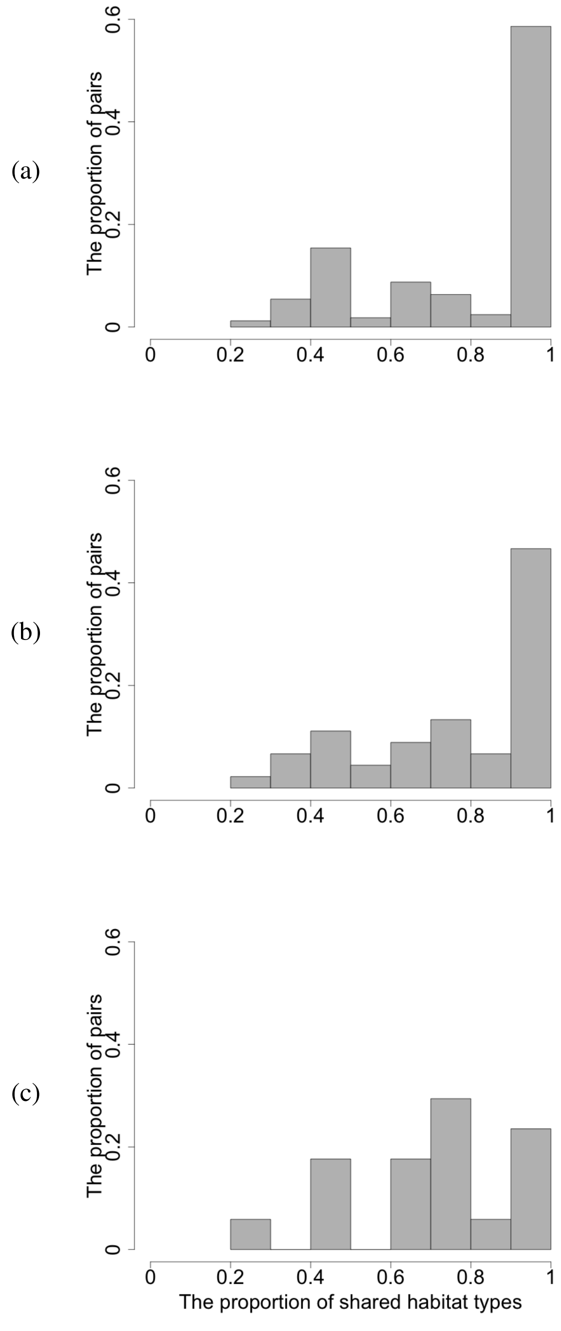


Figure 3.12: The proportion of shared habitat types of sister pairs in different regions for (a) tropical, (b) northern and (c) southern temperate regions. The proportion of pairs were calculated as the proportion of shared habitat types normalized by the total number of species pairs that are present in each region. Note that the value zero is not included since it refers to pairs that do not share habitats.

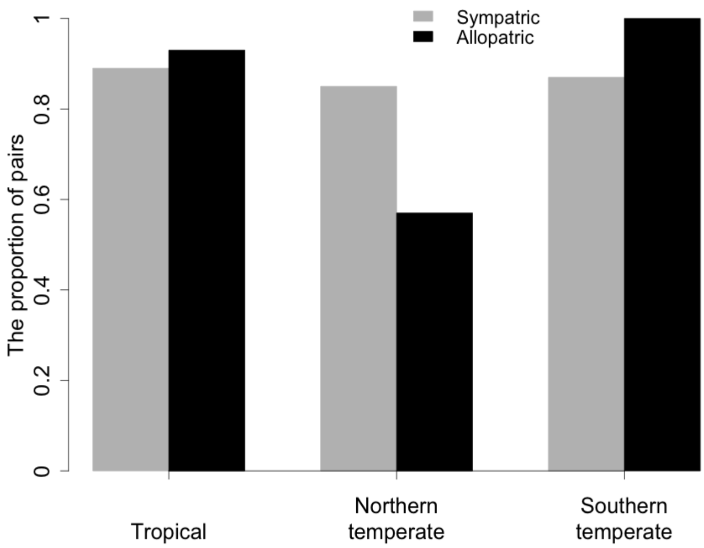


Figure 3.13: The proportion of sister pairs that share habitats within sympatric (shown in gray) and allopatric (shown in black) pairs in tropical, northern and southern temperate regions.

CHAPTER 4

DISCUSSION

High species diversity in tropics is an interesting pattern. Scientists have provided different hypotheses that could cause to latitudinal diversity gradient (Dobzhansky 1950, Pianca 1966, Ricklefs 1973, Rohde 1992, Orme et al. 2005). The time-integrated area hypothesis and the tropical niche conservatism hypothesis both stated that high species diversity in tropics is because of larger biomes and more time to diversification (Fine, 2015). Climatic stability hypothesis states that due to more stable climates in tropics, species have higher speciation rates and low extinction rate (Fine, 2015). Schluter (2016) proposed yet another hypothesis, i.e. ecological opportunity, which states that owing to available niches, and more time to utilize them, tropical species get diversified, even the evolutionary rates in tropics and temperate regions are the same.

Biotic interactions could also play a role in species diversity. Schemske et al. (2009) showed that biotic interactions could be more important in tropics than in temperate regions. Schemske et al. (2009) study remains to be the only study that investigates the potential role of biotic interactions on species diversity. Biotic interactions, competition in particular, are known to determine the limits of species geographic range sizes preventing species ranges overlap (Case and Taper 2000, Price and Kirkpatrick 2009, Price et al. 2014). For example, Herrera-Alsina and Villegas-Patraca (2014) showed that *Peucaea* sparrows limit their ranges and stop expanding due to competition. Competition also limits species ranges when species have similar body sizes due to similar niche requirements (Blackburn et al., 1998).

We tested whether sister species ranges overlap patterns change across latitudes. If biotic interactions are higher in tropics, then range overlap ratios in that region should be less than that of the temperate regions. We studied on sister passerine species in the New World to test our hypothesis. The range overlap ratio patterns of sister passerines in the New World showed that only half of the tropical sister species have overlapping ranges, and when they do, they have small overlap ratios. Conversely, most of the northern temperate species overlap, and that with high proportion of range overlap ratios.

This is exactly what we expected to see in the tropics due to competition, however, there could be several other underlying reasons for the observed pattern. First, checked whether the pattern is due to small range sizes in tropics, since that is what we observed. The results reveal that the pattern continues to hold, i.e. similar range sized species overlap less in the tropics than in the temperate regions. Then, we ruled out the effect of the interaction between species range sizes and the sizes of the regions. Thus, we built a null model, and saw that the observed proportions of sympatric pairs are significantly different. Lastly, we checked the ages of sister pairs from available phylogenetic trees. Since the general mode of speciation for birds is allopatric speciation (Chesser and Zink, 1994), there could be less overlap simply because the sister pair in the tropics could be younger, or vice versa. We found that the observed distributions of range overlap ratios of sister pairs in each region are not related to the ages of pairs.

We should also note that so far in this discussion, we have referred to the temperate region as one, even though the range overlap ratio of sister pairs that are found in southern temperate region does not show a clear pattern. Hawkins and Diniz-Filho (2006) suggested that species have broader range sizes in both mountains and lowlands of northern latitudes; but species range sizes are smaller in the mountains of southern latitudes than in the lowlands. We investigated the role of altitude on overlap patterns (methods and results are available in Appendix C) but the sample sizes were too small. The lack of pattern in the southern temperate region may be due to small land area of the region. Blackburn and Gaston (1996) proposed that decrease in range size toward south of the equator must be due in part to the decreasing land area available for species at that latitude. Ruggiero (2001) studied on Andean passerine birds and found that huge alterations in the topography of Andean mountains affects the size of species ranges.

Also compared body mass ratio of sister pairs with overlapping and not overlapping ranges. We expected to see greater body mass ratios (bigger than 1.5) when there is high overlap. However, we found that the mass ratios are smaller than 1.5 in each region; i.e. sister pairs have similar body masses in each region, and there is no correlation between body mass ratio and range overlap ratio of sister pairs in each region. It is possible that body mass ratio of 1.5 may not be a good indicator of competition between birds, and they differ in traits such as beak size when they compete (Grant and Grant, 2006).

There could be several caveats related to our data set. First, depending on the range data, breeding or total, competition may not be reflected (we used species total range data). Second, we could validate the taxonomic status of 70% of sister taxa in Jetz et al. (2012). Third, we found the ages of only a small portion of sister taxa.

Despite these caveats, we have found a very interesting pattern that less proportion of sister taxa overlap in the tropics, and among those that do, they overlap in smaller proportions of their ranges. The main reason for this pattern remains unknown, but we showed that it is not simply because of the range sizes, the sizes of the regions, or the ages of sister taxa. Even though we failed to demonstrate a difference based on body sizes in overlapping sister pairs, biotic interactions, competition in particular remains to be the main contender behind this pattern we observed. Needless to say, we urge more studies before the tropical diversity disappears (Fine, 2015).

REFERENCES

Aleixo, A. (2002). Molecular systematics and the role of the "Várzea"- "Terra-firme" ecotone in the diversification of *Xiphorhynchus* woodcreepers (Aves: Dendrocolaptidae). *The Auk*, 119(3):621–640.

Aleixo, A., Burlamaqui, T. C. T., Schneider, M. P. C., and Gonçalves, E. C. (2009). Molecular systematics and plumage evolution in the monotypic obligate army-ant-following genus *Skutchia* (Thamnophilidae). *The Condor*, 111(2):382–387.

Álvarez Varas, R., Gonzalez-Acuna, D., and Vianna, J. A. (2009). Comparative phylogeography of co-distributed *Phrygilus* species (Aves, Thraupidae) from the Central Andes. *Molecular Phylogenetics and Evolution*, 111(2):382–387.

Aramaiz-Villena, A., Álvarez Tejado, M., Ruíz-del Valle, V., García-de-la Torre, C., Varela, P., Recio, M. J., Ferre, S., and Martinez-Laso, J. (1998). Phylogeny and rapid northern and southern hemisphere speciation of goldfinches during the Miocene and Pliocene epochs. *Cellular and Molecular Life Sciences*, 54:1031–1041.

Arbeláez-Cortés, E., Nyári, A. S., and Navarro-Sigüenza, A. G. (2010). The differential effect of lowlands on the phylogeographic pattern of a Mesoamerican montane species (*Lepidocolaptes affinis*, Aves: Furnariidae). *Molecular Phylogenetics and Evolution*, 57:658–668.

Barber, B. R. and Rice, N. H. (2007). Systematics and evolution in the Tityrinae (Passeriformes: Tyrannoidea). *The Auk*, 124(4):1317–1329.

Barker, F. K. (2004). Monophyly and relationships of wrens (Aves: Troglodytidae): a congruence analysis of heterogeneous mitochondrial and nuclear DNA sequence data. *Molecular Phylogenetics and Evolution*, 31:486–504.

Barker, F. K. (2007). Avifaunal interchange across the Panamanian Isthmus: insights from *Campylorhynchus* wrens. *Biological Journal of the Linnean Society*, 90:687–702.

Barker, F. K., Burns, K. J., Klicka, J., Lanyon, S. M., and Lovette, I. (2015). New insights into New World biogeography: An integrated view from the phylogeny of blackbirds, cardinals, sparrows, tanagers, warblers, and allies. *The Auk*, 132:333–348.

Barraclough, T. G. and Vogler, A. P. (2000). Detecting the geographical pattern of speciation from species-level phylogenies. *The American Naturalist*, 155(4):419–434.

Bates, J. M., Hackett, S. J., and Goerck, J. M. (1999). High levels of mitochondrial DNA differentiation in two lineages of Antbirds (*Drymophila* and *Hypocnemis*). *The Auk*, 116(4):1093–1106.

Berv, J. S. and Prum, R. O. (2014). A comprehensive multilocus phylogeny of the Neotropical cotingas (Cotingidae, Aves) with a comparative evolutionary analysis of breeding system and plumage dimorphism and a revised phylogenetic classification. *Molecular Phylogenetics and Evolution*, 81:120–136.

BirdLife International (2016). IUCN Red List for birds. http://www.birdlife.org.

Bivand, R., Keitt, T., and Rowlingson, B. (2015). rgdal: Bindings for the geospatial data abstraction library. r package version 1.0-4. http://CRAN.R-project.org/package=rgdal.

Bivand, R. and Lewin-Koh, N. (2015). maptools: Tools for reading and handling spatial objects. r package version 1.0-4. http://CRAN.R-project.org/package=maptools.

Bivand, R. and Rundel, C. (2015). rgeos: Interface to geometry engine - open source (geos). r package version 0.3-11. http://CRAN.R-project.org/package=rgeos.

Blackburn, T. M. and Gaston, K. J. (1996). Spatial patterns in the geographic range sizes of bird species in the New World. *Philosophical Transactions of Royal Society B*, 351:897–912.

Blackburn, T. M. and Gaston, K. J. (1997). The relationship between geographic area and the latitudinal gradient in species richness in New World birds. *Evolutionary Ecology*, 11:195–204.

Blackburn, T. M., J, G. K., and H, L. J. (1998). Patterns in the geographic ranges of the world's woodpeckers. *Ibis*, 140:626–638.

Bonaccorso, E. (2009). Historical biogeography and speciation in the Neotropical highlands: molecular phylogenetics of the jay genus *Cyanolyca*. *Molecular Phylogenetics and Evolution*, 50:618–632.

Bonaccorso, E. and Peterson, A. T. (2007). Molecular systematics and evolution of the *Cyanocorax* jays. *Molecular Phylogenetics and Evolution*, 42:467–476.

Bonaccorso, E., Peterson, A. T., Navarro-Sigüenza, A. G., and Fleischer, R. C. (2010). Molecular systematics and evolution of the *Cyanocorax* jays. *Molecular Phylogenetics and Evolution*, 54:897–909.

Bowers, M. A. and Brown, J. H. (1982). Body size and coexistence in desert rodents: chance or community structure? *Ecology*, 63:391–400.

Boyle, W. A. (2006). Why do birds migrate? The role of food, habitat, predation and competition.

Bravo, G. A., Chesser, R. T., and Brumfield, R. T. (2012a). DNA sequence data reveal a subfamily-level divergence within Thamnophilidae (Aves: Passeriformes). *Molecular Phylogenetics and Evolution*, 65:287–293.

Bravo, G. A., Chesser, R. T., and Brumfield, R. T. (2012b). *Isleria*, a new genus of antwren (Aves: Passeriformes: Thamnophilidae). *Zootaxa*, 3195:61–67.

Britton, T., Andersson, C. L., Jacquet, D., S, L., and Bremer, K. (2006). PATHd8 - a program for phylogenetic dating of large trees without a molecular clock. http://www.math.su.se/PATHd8/.

Brown, J. H. (1973). Species diversity of seed-eating desert rodents in sand dune habitats. *Ecology*, 54:775–787.

Brumfield, R. T. and Braun, M. J. (2001). Phylogenetic relationships in bearded manakins (Pipridae: Manacus) indicate that male plumage color is a misleading taxonomic marker. *The Condor*, 103:248–258.

Brumfield, R. T. and Edwards, S. V. (2007). Evolution into and out of the Andes: a bayesian analysis of historical diversification in *Thamnophilus* antshrikes. *Evolution*, 61:346–367.

Brumfield, R. T., Tello, J. G., Cheviron, Z. A., Carling, M. D., Crochet, N., and Rosenberg, K. V. (2007). Phylogenetic conservatism and antiquity of a tropical specialization: Army-ant-following in the typical antbirds (Thamnophilidae). *Molecular Phylogenetics and Evolution*, 45:1–13.

Bullock, J. M., Edwards, R. J., Carey, P. D., and Rose, R. J. (2000). Geographical separation of *Ulex* species at three spatial scales: does competition limit species' ranges? *Ecography*, 23(3):257–271.

Burns, K. J. (1998). Molecular phylogenetics of the genus *Piranga*: implications for biogeography and the evolution of morphology and behavior. *The Auk*, 115(3):621–634.

Burns, K. J., Hackett, S. J., and Klein, N. K. (2002). Phylogenetic relationships and morphological diversity in Darwin?s finches and their relatives. *Evolution*, 56(6):1240–1252.

Burns, K. J. and Naoki, K. (2004). Molecular phylogenetics and biogeography of Neotropical tanagers in the genus *Tangara*. *Molecular Phylogenetics and Evolution*, 32:838–854.

Burns, K. J., Shultz, A. J., Title, P. O., Mason, N. A., Barker, F. K., Klicka, J., Lanyon, S. M., and Lovette, I. J. (2014). Phylogenetics and diversification of tanagers (Passeriformes: Thraupidae), the largest radiation of Neotropical songbirds. *Molecular Phylogenetics and Evolution*, 75:41–77.

Cadena, C. D., Cuervo, A. M., and Lanyon, S. M. (2004). Phylogenetic relationships of the red-bellied grackle (Icteridae: *Hypopyrrhus Pyrohypogaster*) inferred from mitochondrial DNA sequence data. *The Condor*, 106:664–670.

Campagna, L., Geale, K., Handford, P., Lijtmaer, D. A., Tubaro, P. L., and Lougheed, S. J. (2011). A molecular phylogeny of the Sierra-Finches (*Phrygilus*, Passeriformes): extreme polyphyly in a group of Andean specialists. *Molecular Phylogenetics and Evolution*, 61:521–533.

Carson, R. J. and Spicer, G. S. (2003). A phylogenetic analysis of the emberizid sparrows based on three mitochondrial genes. *Molecular Phylogenetics and Evolution*, 29:43–57.

Case, T. J. and Taper, M. L. (2000). Interspecific competition, environmental gradients, gene flow, and the coevolution of species? borders. *The American naturalist*, 155(5):583–605.

Chaves, J. A., Hidalgo, J. R., and Klicka, J. (2013). Biogeography and evolutionary history of the Neotropical genus *Saltator* (Aves: Thraupini). *Journal of Biogeography*, 40:2180–2190.

Chaves, V. A., Clozato, C. L., Lacerda, D. R., Sari, E. H. R., and Santos, F. R. (2008). Molecular taxonomy of Brazilian tyrant-flycatchers (Passeriformes: Tyrannidae). *Molecular Ecology Resources*, 8:1169–1177.

Chesser, R. T. (2000). Evolution in the high Andes: the phylogenetics of *Muscisaxicola* Ground-Tyrants. *Molecular Phylogenetics and Evolution*, 15(3):369–380.

Chesser, R. T. (2004). Systematics, evolution, and biogeography of the South American ovenbird genus *Cinclodes*. *The Auk*, 121(3):752–766.

Chesser, R. T., K, B. F., and Brumfield, R. T. (2007). Fourfold polyphyly of the genus formerly known as *Upucerthia*, with notes on the systematics and evolution of the avian subfamily Furnariinae. *Molecular Phylogenetics and Evolution*, 44:1320–1332.

Chesser, R. T. and Zink, R. M. (1994). Modes of speciation in birds: a test of Lynch's method. *Evolution*, 48(2):490–497.

Cheviron, Z. A., Capparella, A. P., and Vuilleumier, F. (2005). Molecular phylogenetic relationships among the *Geositta* miners (Furnariidae) and biogeographic implications for avian speciation in Fuego-Patagonia. *The Auk*, 122(1):158–174.

Claramunt, S., Derryberry, E. P., Cadena, C. D., Cuervo, A. M., Sanin, C., and Brumfield, R. T. (2013). Phylogeny and classification of *Automolus* foliage-gleaners and allies (Furnariidae). *The Condor*, 115(2):375–385.

Claramunt, S., Derryberry, E. P., Chesser, R. T., Aleixo, A., and Brumfield, R. T. (2010). Polyphyly of *Campylorhamphus*, and description of a new genus for *C. Pucherani* (Dendrocolaptinae). *The Auk*, 122(2):430–439.

DaCosta, J. M., M, S. G., P, E., and Klicka, J. (2009). A molecular systematic revision of two historically problematic songbird clades: *Aimophila* and *Pipilo*. *Journal of Avian Biology*, 40:206–216.

Dempsey, C. (August 25, 2014). Latitude and longitude. https://www.geolounge.com/latitude-longitude/.

Derryberry, E., Claramunt, S., O'Quin, K. E., Aleixo, A Chesser, R. T., Remsen, J. V., and Brumfield, R. T. (2010). *Pseudasthenes*, a new genus of ovenbird (Aves: Passeriformes: Furnariidae). *Zootaxa*, 2416:61–68.

Dobzhansky, T. (1950). Evolution in the tropics. *Journal of Animal Science*, 38:208–221.

Drummond, A. J. and Rambaut, A. (2007). BEAST: Bayesian evolutionary analysis by sampling trees. *BMC Evolutionary Biology*, 7:214.

Dunning, J. (2008). *Handbook of Avian Body Masses, 2nd edn*. CRC Press, Boca Raton.

Ericson, P. G. P., Olson, S. L., Irestedt, M., Alvarenga, H., and Fjeldså, J. (2010). Circumscription of a monophyletic family for the tapaculos (Aves: Rhinocryptidae): *Psiloramphus* in and *Melanopareia* out. *Journal of Ornithology*, 151:337–345.

Fernandes, A. M., Wink, M., Sardelli, C. H., and Aleixo, A. (2014). Multiple speciation across the Andes and throughout Amazonia: the case of the spot-backed antbird species complex (*Hylophylax naevius*/ *Hylophylax naevioides*). *Journal of Biogeography*, 41:1094–1104.

Ferrer, X., Motis, A., and Peris, S. J. (1991). Changes in the breeding range of starlings in the Iberian peninsula during the last 30 years: competition as a limiting factor. *Journal of Biogeography*, 18:373–383.

Fine, P. V. A. (2015). Ecological and evolutionary drivers of geographic variation in species diversity. *Annual Review of Ecology, Evolution, and Systematics*, 46:369–392.

Fine, P. V. A. and Ree, R. H. (2006). Evidence for a time-integrated species-area effect on the latitudinal gradient in tree diversity. *The American Naturalist*, 168:796–804.

García-Moreno, J., Arctander, P., and Fjeldså, J. (1999). A case of rapid diversification in the Neotropics: phylogenetic relationships among *Cranioleuca* spinetails (Aves, Furnariidae). *Molecular Phylogenetics and Evolution*, 12(3):273–281.

Gill, F. B., Slikas, B., and Sheldon, F. H. (2005). Phylogeny of titmice (Paridae): II. species relationships based on sequences of the mitochondrial cytochrome-b gene. *The Auk*, 122(1):121–143.

Gonzalez, J. (2014). Phylogenetic position of the most endangered Chilean bird: the Masafuera Rayadito (*Aphrastura masafuerae*; Furnariidae). *Tropical Conservation Science*, 7(4):677–689.

Grant, P. R. and Grant, B. R. (2006). Evolution of character displacement in Darwin?s finches. *Science*, 313:224–226.

H, R. N. (2005). Phylogenetic relationships of *Antpitta* genera (Passeriformes: Formicariidae). *The Auk*, 122(2):673–683.

Hackett, S. J. (1993). Phylogenetic and biogeographic relationships in the Neotropical genus *Gymnopithys* (Formicariidae). *Wilson Ornithological Society*, 105(2):301–315.

Hackett, S. J. and Rosenberg, K. V. (1990). Comparison of phenotypic and genetic differentiation in South American Antwrens (Formicariidae). *American Ornithologists' Union*, 107(3):473–489.

Haring, E., Daubl, B., Pinsker, W., Kryukov, A., and Gamauf, A. (2012). Genetic divergences and intraspecific variation in corvids of the genus *Corvus* (Aves: Passeriformes: Corvidae) - a first survey based on museum specimens. *Journal of Zoological Systematics and Evolutionary Research*, 50(3):230–246.

Hawkins, B. A. and Diniz-Filho, J. A. F. (2006). Beyond Rapoport's rule: evaluating range size patterns of New World birds in a two-dimensional framework. *Global Ecology and Biogeography*, 15(5):461–469.

Heller, E. L., Kerr, K. C. R., Dahlan, N. F., Dove, C. J., and Walters, E. L. (2016). Overcoming challenges to morphological and molecular identification of *Empidonax* flycatchers: a case study with a Dusky Flycatcher. *Journal of Field Ornithology*, 87(1):96–103.

Herrera-Alsina, L. and Villegas-Patraca, R. (2014). Biologic interactions determining geographic range size: a one species response to phylogenetic community structure. *Ecology and Evolution*, 4(7):968–976.

Hosner, P. A. and Moyle, R. G. (2012). A molecular phylogeny of black-tyrants (Tyrannidae: *Knipolegus*) reveals strong geographic patterns and homoplasy in plumage and display behavior. *The Auk*, 129(1):156–167.

Hunt, J. S., Bermingham, E., and Ricklefs, R. E. (2001). Molecular systematics and biogeography of Antillean thrashers, tremblers, and mockingbirds (Aves: Mimidae). *The Auk*, 118(1):35–55.

Irestedt, M., Fjeldså, J., Dalen, L., and Ericson, P. G. P. (2004). Phylogenetic relationships of woodcreepers (Aves: Dendrocolaptinae) incongruence between molecular and morphological data. *Journal of Avian Biology*, 35:280–288.

Irestedt, M., Fjeldså, J., Dalen, L., and Ericson, P. G. P. (2009). Convergent evolution, habitat shifts and variable diversification rates in the ovenbird-woodcreeper family (Furnariidae). *BMC Evolutionary Biology*, 9:268.

Isler, M. L., Bravo, G. A., and Brumfield, R. T. (2013). Taxonomic revision of *Myrmeciza* (Aves: Passeriformes: Thamnophilidae) into 12 genera based on phylogenetic, morphological, behavioral, and ecological data. *Zootaxa*, 3717(4):469–497.

Jablonski, D., Roy, K., and Valentine, J. W. (2006). Out of the tropics: evolutionary dynamics of the latitudinal diversity gradient. *Science*, 314:102–106.

Jetz, W., Thomas, G. H., Joy, J. B., Hartman, K., and Mooers, A. O. (2012). The global diversity of birds in space and time. *Nature*, 491:444–448.

Johansson, U. S., Ekman, J., Bowie, R. J. K., Halvarson, P Ohlson, J. I., Price, T. D., and Ericson, P. G. P. (2013). A complete multilocus species phylogeny of the tits and chickadees (Aves: Paridae). *Molecular Phylogenetics and Evolution*, 69:852–860.

Johansson, U. S., Irestedt, M., and Parsons, T J Ericson, P. G. P. (2002). Basal phylogeny of the Tyrannoidea based on comparisons of cytochrome B and exons of nuclear c-myc and RAG-1 genes. *The Auk*, 119(4):984–995.

Johnson, N. K. and Cicero, C. (2002). The role of ecologic diversification in sibling speciation of *Empidonax* flycatchers (Tyrannidae): multigene evidence from mtDNA). *Molecular Ecology*, 11:2065–2081.

Joseph, L., Wilke, T., Bermingham, E., Alpers, D., and Ricklefs, R. (2004). Towards a phylogenetic framework for the evolution of shakes, rattles, and rolls in *Myiarchus* tyrant-flycatchers (Aves: Passeriformes: Tyrannidae). *Molecular Phylogenetics and Evolution*, 31:139–152.

Kerkhoff, A. J., Moriarty, P. E., and Weiser, M. D. (2014). The latitudinal species richness gradient in New World woody angiosperms is consistent with the tropical conservatism hypothesis. *PNAS*, 111:8125–8130.

Klicka, J., , and Spellman, G. M. (2007a). A molecular evaluation of the North American ?grassland? sparrow clade. *The Auk*, 124(2):537–551.

Klicka, J., Burns, K., and Spellman, G. M. (2007b). Defining a monophyletic Cardinalini: A molecular perspective. *Molecular Phylogenetics and Evolution*, 45:1014–1032.

Klicka, J., Voelker, G., and Spellman, G. M. (2005). A molecular phylogenetic analysis of the ??true thrushes?? (Aves: Turdinae). *Molecular Phylogenetics and Evolution*, 34:486–500.

Krabbe, N. and Cadena, C. D. (2010). A taxonomic revision of the Paramo Tapaculo *Scytalopus canus* Chapman (Aves: Rhinocryptidae), with description of a new subspecies from Ecuador and Peru. *Zootaxa*, 2354:56–66.

Lanyon, S. M. (1994). Polyphyly of the blackbird genus *Agelaius* and the importance of assumptions of monophyly in comparative studies. *Evolution*, 48(3):679–693.

Lanyon, S. M. and Omland, K. E. (1999). A molecular phylogeny of the blackbirds (Icteridae): five lineages revealed by cytochrome-b sequence data. *The Auk*, 116(3):629–639.

Lanyon, W. E. and Lanyon, S. M. (1986). Generic status of Euler's flycatcher: a morphological and biochemical study. *The Auk*, 103(2):341–350.

Letcher, A. J., Purvis, A., Nee, S., and Harvey, P. H. (1994). Patterns of overlap in the geographic ranges of Palearctic and British mammals. *Journal of Animal Ecology*, 64:871–879.

Lijtmaer, D. A., Sharpe, N. M. M., Tubaro, P. L., and Lougheed, S. C. (2004). Molecular phylogenetics and diversification of the genus *Sporophila* (Aves: Passeriformes). *Molecular Phylogenetics and Evolution*, 33:562–579.

Lovette, I. J., Arbogast, B. S., Curry, R. L., Zink, R. M., Botero, C. A., Sullivan, J. P., Talaba, R. B., Rubenstein, D. R., Ricklefs, R. E., and Bermingham, E. (2012). Phylogenetic relationships of the mockingbirds and thrashers (Aves: Mimidae). *Molecular Phylogenetics and Evolution*, 63:219–229.

Lovette, I. J. and Bermingham, E. (1999). Explosive speciation in the New World *Dendroica* warblers. *The Royal Society*, 266:1629–1636.

Lovette, I. J., Pérez-Emán, J. L., Sullivan, J. P., Banks, R. C., Fiorentino, I., Córdoba-Córdoba, S., Echeverry-Galvis, M., Barker, F. K., Burns, K. J., Klicka, J., Lanyon, S., and Bermingham, E. (2010). A comprehensive multilocus phylogeny for the wood-warblers and a revised classification of the Parulidae (Aves). *Molecular Phylogenetics and Evolution*, 57:753–770.

Lovette, I. J. and Rubenstein, D. R. (2007). A comprehensive molecular phylogeny of the starlings (Aves: Sturnidae) and mockingbirds (Aves: Mimidae): Congruent mtDNA and nuclear trees for a cosmopolitan avian radiation. *Molecular Phylogenetics and Evolution*, 44:1031–1056.

Mann, N. I., Barker, F. K., Graves, J. A., Dingess-Mann, K. A., and Slater, P. J. B. (2006). Molecular data delineate four genera of "*Thryothorus*" wrens. *Molecular Phylogenetics and Evolution*, 40:750–759.

Martínez Goméz, J. E., Barber, B. R., and Peterson, A. T. (2005). Phylogenetic position and generic placement of the socorro wren (*Thryomanes Sissonii*). *The Auk*, 122(1):50–56.

Mason, N. A. and Burns, K. J. (2013). Molecular phylogenetics of the Neotropical seedeaters and seed-finches (Sporophila, Oryzoborus, Dolospingus). *Ornitologia Neotropical*, 24(1):139–155.

Mata, H., Fontana, C. S., Maurício, G. N., Bornschein, M. R., Vasconcelos, M. F., and Bonatto, S. L. (2009). Molecular phylogeny and biogeography of the eastern Tapaculos (Aves: Rhinocryptidae: *Scytalopus, Eleoscytalopus*): cryptic diversification in Brazilian Atlantic Forest. *Molecular Phylogenetics and Evolution*, 53(1):450–462.

McCormack, J. E., Haled, J., Delaney, K. S., Peterson, A. T., and Knowles, L. L. (2010). Calibrating divergence times on species trees versus gene trees: implications for speciation history of *Aphelocoma* jays. *Evolution*, 65(1):184–202.

McCormack, J. E., Peterson, A. T., Bonaccorso, E., and Smith, T. B. (2008). Speciation in the highlands of Mexico: genetic and phenotypic divergence in the Mexican jay (*Aphelocoma ultramarina*). *Molecular Ecology*, 17:2505–2521.

Miller, M. J., Bermingham, E., Klicka, J., Escalante, P., Amaral, F. S. R., Weir, J. T., and Winker, K. (2008). Out of Amazonia again and again: episodic crossing of the Andes promotes diversification in a lowland forest flycatcher. *Proceeding of Royal Society B*, 275:1133–1142.

Miller, M. J., Bermingham, E., and Ricklefs, R. E. (2007). Historical biogeography of the new world solitaires (*Myadestes* spp) jays. *The Auk*, 124(3):868–885.

Mobley, J. A. and Prum, R. O. (1995). Phylogenetic relationships of the cinnamon tyrant, *Neopipo cinnamomea*, to the tyrant flycatchers (Tyrannidae). *The Condor*, 97(3):650–662.

Moritz, C., Patton, J. L., Schneider, C. J., and Smith, T. B. (2000). Diversification of rainforest faunas: an integrated molecular approach. *Annual Review of Ecology, Evolution, and Systematics*, 31:533?563.

Moyle, R. G., Chesser, R. T., Brumfield, R. T., Tello, J. G., Marchese, D. J., and Cracraft, J. (2009). Phylogeny and phylogenetic classification of the antbirds, ovenbirds, woodcreepers, and allies (Aves: Passeriformes: infraorder Furnariides). *Cladistics*, 25:386–405.

Nylander, J. A. A., Olsson, U., Alström, P., and Sanmartín, I. (2008). Accounting for phylogenetic uncertainty in biogeography: a Bayesian approach to dispersal-vicariance analysis of the thrushes (Aves: *Turdus*). *Society of Systematic Biologists*, 57(2):257–268.

Ohlson, J., Fjeldså, J., and Ericson, P. G. P. (2008). Tyrant flycatchers coming out in the open: phylogeny and ecological radiation of Tyrannidae (Aves, Passeriformes). *Zoologica Scripta*, 37:315–335.

Ohlson, J., Fjeldså, J., and Ericson, P. G. P. (2013). Molecular phylogeny of the manakins (Aves: Passeriformes: Pipridae), with a new classification and the description of a new genus. *Molecular Phylogenetics and Evolution*, 69:796–804.

Ohlson, J., Prum, R. O., and Ericson, P. G. P. (2007). A molecular phylogeny of the cotingas (Aves: Cotingidae). *Molecular Phylogenetics and Evolution*, 42:25?37.

Orme, C. D. L., Davies, R. G., Burgess, M., Eigenbord, F., Pickup, N., Olson, V. A., Webster, A. J., Ding, T., Rasmussen, P. C., Ridgely, R. S., Stattersfield, A. J., Bennett, P. M., Blackburn, T. M., Gaston, K. J., and Owens, I. P. F. (2005). Global hotspots of species richness are not congruent with endemism or threat. *Nature*, 436:1016–1019.

Outlaw, D. C., Voelker, G., Mila, B., and Girman, D. j. (2003). Evolution of long-distance migration in and historical biogeography of *Catharus* thrushes: a molecular phylogenetic approach. *The Auk*, 120(2):299–310.

Pianca, E. R. (1966). Latitudinal gradients in species diversity: a review of concepts. *The American Naturalist*, 100:33–46.

Price, J. J. and Lanyon, S. M. (2002). A robust phylogeny of the Oropendolas: polyphyly revealed by mitochondrial sequence data. *The Auk*, 119(2):335–348.

Price, J. J. and Lanyon, S. M. (2003). Patterns of song evolution and sexual selection in the Oropendolas and Caciques. *Behavioral Ecology*, 15(3):485–497.

Price, J. J. and Lanyon, S. M. (2010). Phylogenetic relationships of the white-throated barbtail, *Premnoplex tatei* (Furnariidae), an endemic of the northeastern mountain range of Venezuela. *The Condor*, 112(3):561–570.

Price, T. D., Hooper, D. M., Buchanan, C. D., Johansson, U. S., Tietze, D. T., Alström, P., Olsson, U., Ghosh-Harihar, M., Ishtiaq, F., Gupta, S. K., Martens, J., Harr, B., Singh, P., and Mohan, D. (2014). Niche filling slows the diversification of Himalayan songbirds. *Nature*, 509:222–225.

Price, T. D. and Kirkpatrick, M. (2009). Evolutionary stable range limits set by interspecific competition. *Proceedings of the Royal Society B*, 276:1429–1434.

Prum, R. O. (1997). Phylogenetic tests of alternative intersexual selection mechanisms: trait macroevolution in a Polygynous clade (Aves: Pipridae). *The American Naturalist*, 149(4):668–692.

Prum, R. O. (1998). Sexual selection and the evolution of mechanical sound production in manakins (Aves: Pipridae). *Animal Behaviour*, 5(0):977–994.

R Development Core Team (2010). R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at http://www.R-project.org/.

Raikow, R. J. (1986). Why are there so many kinds of passerine birds? *Society of Systematic Biologists*, 35(2):255–259.

Raikow, R. J. (1994). A phylogeny of the woodcreepers (Dendrocolaptinae). *The Auk*, 111(1):104–114.

Rheindt, F. E., Christidis, L., and Norman, J. A. (2008). Habitat shifts in the evolutionary history of a Neotropical flycatcher lineage from forest and open landscapes. *BMC Evolutionary Biology*, 8(0):193.

Rheindt, F. E., Christidis, L., and Norman, J. A. (2009). Genetic introgression, incomplete lineage sorting and faulty taxonomy create multiple cases of polyphyly in a montane clade of tyrant-flycatchers (Elaenia, Tyrannidae). *Zoologica Scripta*, 38(2):143?153.

Rheindt, F. E., Norman, J. A., and Christidis, L. (2007). Phylogenetic relationships of tyrant-flycatchers (Aves: Tyrannidae), with an emphasis on the *Elaeniine* assemblage. *Molecular Phylogenetics and Evolution*, 46(0):88–101.

Ricklefs, R. E. (1973). *Ecology*. Nelsons & Sons, London.

Ridgely, R. S., Allnutt, T. F., Brooks, T., McNicol, D. K., Mehlman, D. W., Young, B. E., and Zook, J. R. (2003). Digital distribution maps of the birds of the western hemisphere. Version 1.0. NatureServe, Arlington, Virginia.

Rohde, K. (1992). Latitudinal gradients in species diversity: the search for the primary cause. *Oikos*, 65(3):514–527.

Rosser, N., Kozak, K. M., Phillimore, A. B., and Mallet, J. (2015). Extensive range overlap between heliconiine sister species: evidence for sympatric speciation in butterflies? *BMC Evolutionary Biology*, 15(125).

Roy, M. S., Torres-Mura, J. C., and Hertel, F. (1999). Molecular phylogeny and evolutionary history of the tit-tyrants (Aves: Tyrannidae). *Molecular Phylogenetics and Evolution*, 11(1):67?76.

Ruggiero, A. (2001). Size and shape of the geographical ranges of Andean passerine birds: spatial patterns in environmental resistance and anisotropy. *Journal of Biogeography*, 28:1281–1294.

Sánchez-González, L. A., Navarro-Sigüenza, A. G., Krabbe, N. K., Fjeldså, J., and Gárcia-Moreno, J. (2015). Diversification in the Andes: the Atlapetes brush-finches. *Zoologica Scripta*, 44:135–152.

Sari, E. H. R. and Parker, P. G. (2012). Understanding the colonization history of the Galapagos flycatcher (*Myiarchus magnirostris*). *Molecular Phylogenetics and Evolution*, 63:244–254.

Saunders, M. A. and Edwards, S. V. (2000). Dynamics and phylogenetic implications of mtDNA control region sequences in New World jays (Aves: Corvidae). *Journal of Molecular Evolution*, 51:97–109.

Schemske, D. W., Mittelbach, G. G., Cornell, H. V., Sobel, J. M., and Roy, K. (2009).

Is there a latitudinal gradient in the importance of biotic interactions? *Annual Review of Ecology, Evolution, and Systematics*, 40:245–269.

Schluter, D. (2016). Speciation, ecological opportunity, and latitude. *The American Naturalist*, 187(1):1–18.

Sedano, R. E. and Burns, K. J. (2010). Are the Northern Andes a species pump for Neotropical birds? Phylogenetics and biogeography of a clade of Neotropical tanagers (Aves: Thraupini). *Journal of Biogeography*, 37:325–343.

Sheldon, F. H., Whittingham, L. A., Moyle, R. G., Slikas, B., and Winkler, D. W. (2005). Phylogeny of swallows (Aves: Hirundinidae) estimated from nuclear and mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution*, 35:254–270.

Shultz, A. J. and Burns, K. J. (2013). Plumage evolution in relation to light environment in a novel clade of Neotropical tanagers. *Molecular Phylogenetics and Evolution*, 66:112–125.

Stevens, G. C. (1989). The latitudinal gradient in geographical range: how so many species coexist in the tropics. *The American Naturalist*, 133(2):240–256.

Tello, J. G. and Bates, J. M. (2007). Moleculer phylogenetics of the tody-tyrant and flatbill assemblage of tyrant flycatchers (Tyrannidae). *The Auk*, 124(1):134–154.

Tello, J. G., Moyle, R. G., Marchese, D. J., Bravo, G. A., and Cracraft, J. (2009). Reassessment of the systematics of the widespread Neotropical genus *Cercomacra* (Aves: Thamnophilidae). *Cladistics*, 25(0):429–467.

Tello, J. G., Raposo, M., Bates, J. M., Bravo, G. A., Cadena, C. D., and Maldonado-Coelho, M. (2014). Reassessment of the systematics of the widespread Neotropical genus *Cercomacra* (Aves: Thamnophilidae). *Zoological Journal of the Linnean Society*, 170(0):546–565.

Tietze, D. T., Päckert, M., Martens, J., Lehmann, H., and Sun, Y. (2013). Complete phylogeny and historical biogeography of true rosefinches (Aves: *Carpodacus*). *Zoological Journal of the Linnean Society*, 169(0):215–234.

U.S. Geological Survey (1996). Global 30 Arc-Second Elevation. https://lta.cr.usgs.gov/GTOPO30.

Voelker, G. (1999). Dispersal, vicariance, and clocks: historical biogeography and speciation in a cosmopolitan passerine genus (*Anthus*: Motacillidae). *Evolution*, 53(5):1536–1552.

Weir, J. T. and Price, M. (2011). Andean uplift promotes lowland speciation through vicariance and dispersal in *Dendrocincla* woodcreepers. *Molecular Ecology*, 20(0):4550–4563.

Wiens, J. J. (2004). Speciation and ecology revisited: phylogenetic niche conservatism and the origin of species. *Evolution*, 58:193–197.

Wiens, J. J. and Donoghue, M. J. (2004). Historical biogeography, ecology and species richness. *Trends in Ecology and Evolution*, 19:639–644.

Willig, M. R., Kaufman, D. M., and Stevens, R. D. (2003). Latitudinal gradients of biodiversity: pattern, process, scale and synthesis. *Annual Review of Ecology, Evolution, and Systematics*, 34:273–309.

Yuri, T. and Mindell, D. P. (2002). Molecular phylogenetic analysis of Fringillidae, ??New World nine-primaried oscines?? (Aves: Passeriformes). *Molecular Phylogenetics and Evolution*, 23(0):229–243.

Zink, R. M., Blackwell-Rago, R. C., and Ronquist, F. (2000). The shifting roles of dispersal and vicariance in biogeography. *The Royal Society*, 267:497–503.

Zink, R. M., Dittmann, D. L., Klicka, J., and Blackwell-Rago, R. C. (1999). Evolutionary patterns of morphometrics, allozymes, and mitochondrial DNA in Thrashers (Genus *Toxostoma*). *The Auk*, 116(4):1021–1038.

Zink, R. M. and Johnson, N. K. (1984). Evolutionary genetics of flycatchers. I. Sibling species in the genera Empidonax and Contopus. *Society of Systematic Biologists*, 33(2):205–216.

APPENDIX A

SUPPLEMENTARY FIGURES

The supplementary, Appendix A includes two figures that represents the range size distribution of sister species that are found in each region were fitted to Weibull distribution, and geographic maps of three sister pairs whose range centroids are in the same region, however, their overlap centroids are located in different regions. Figures are in following pages.

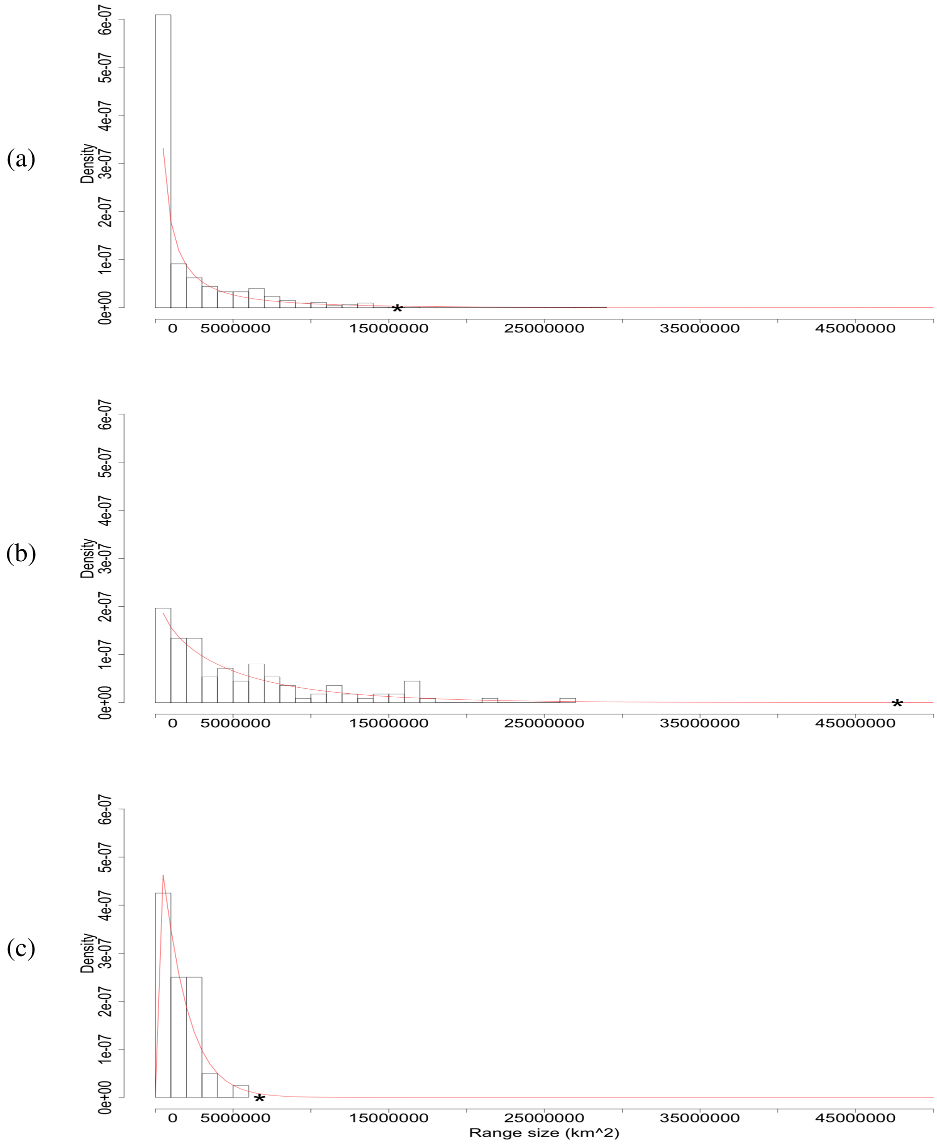


Figure A.1: The range size distribution of sister species that are found in (a) tropical region, (b) northern and (c) southern temperate regions were fitted to Weibull distribution. In the null model, species range sizes for each region were drawn randomly based on the parameters of Weibull distributions fitted above. Starred values show the total land area of those regions (tropical region is 15.5 million km^2, northern temperate region is 47.7 million km^2, and southern temperate region is 6.7 million km^2).

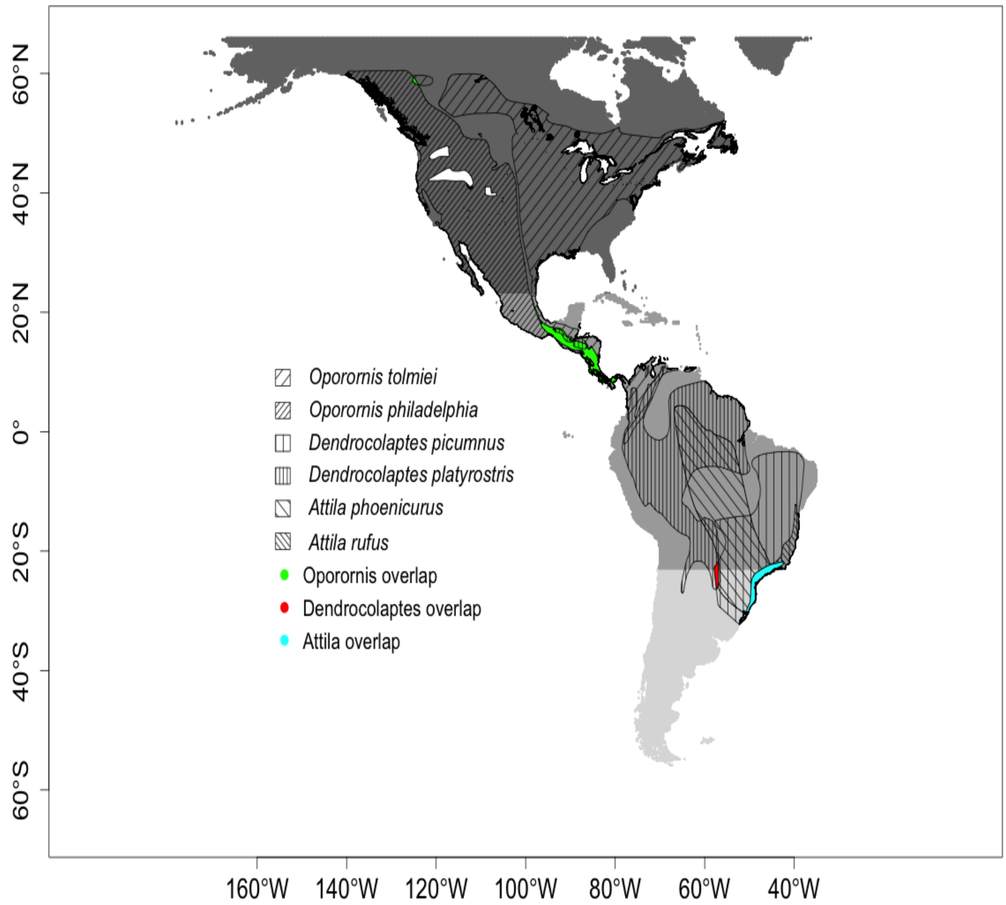


Figure A.2: Geographic maps of three sister pairs whose range centroids are in the same region, however, their overlap centroids are located in different regions. We include them in the "mixed" category in Figure 3.1. *Oporornis philadelphia* and *Oporornis tolmiei* are a northern temperate pair whose overlap centroid in tropics (in green); *Dendrocolaptes platyrostris* and *Dendrocolaptes picumnus*, and *Attila phoenicurus* and *Attila rufus* are 2 tropical pairs whose overlap centroids in southern temperate region (in red and cyan respectively).

APPENDIX B

RESULTS WITH ALL PAIRS INCLUDED

Here, we present results where we include the pairs, we define as “mixed” in Section 3.1. Including “mixed” species do not alter the patterns presented in the main text. We assigned these “mixed” pairs to regions based on their overlap centroids (Fig. B.1, Fig. B.2, Fig. B.4). In Figure B.3, we included all species based on their range centroids.

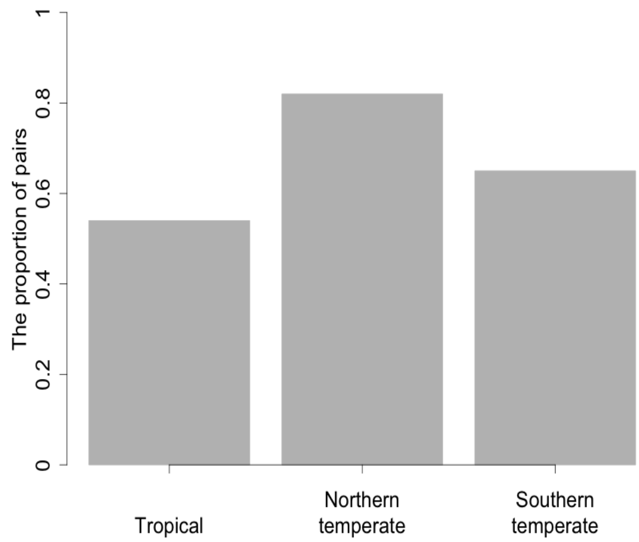


Figure B.1: The proportion of species that are sympatric in tropical, northern and southern temperate regions (total number of species n_T=833, n_{NT}=143, and n_{ST}=120 respectively). Note the decline in the southern temperate region compared to the results in Fig 3.2 when “mixed” species are excluded.

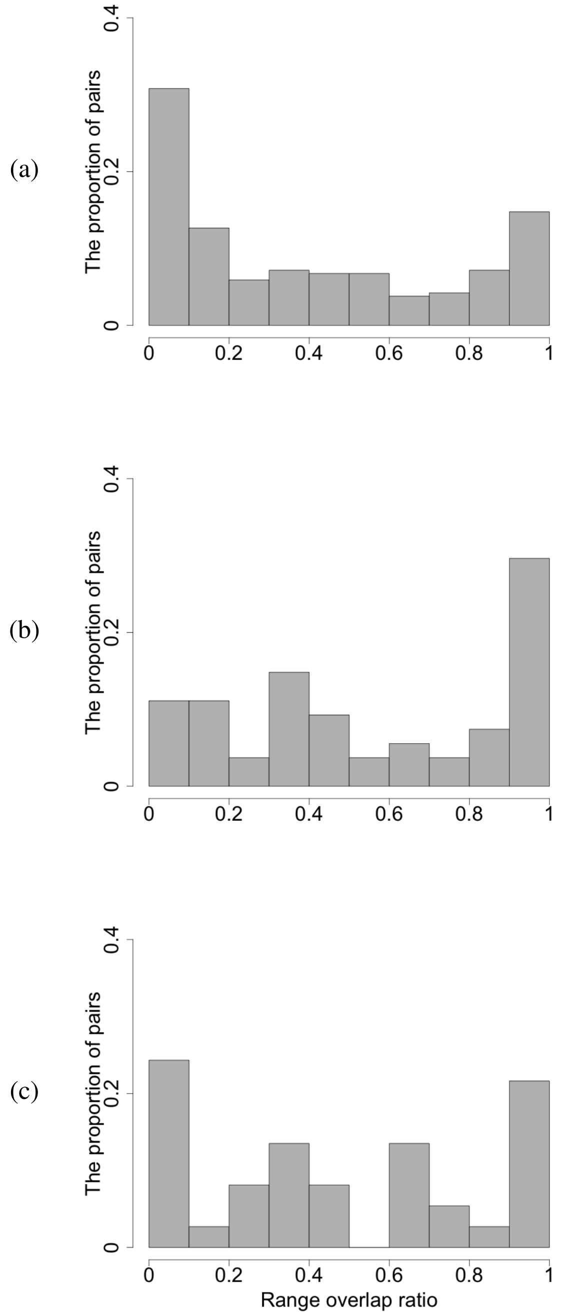


Figure B.2: The proportion of range overlap ratios of sympatric sister pairs in different regions for (a) tropical, (b) northern and (c) southern temperate regions. The proportion of species were calculated as sympatric pairs' range overlap ratio normalized by the total number of species pairs that are present in each region (P_T=237, P_{NT}=54, and P_{ST}=37 respectively). Note that the value zero is not included since it refers to allopatric species.

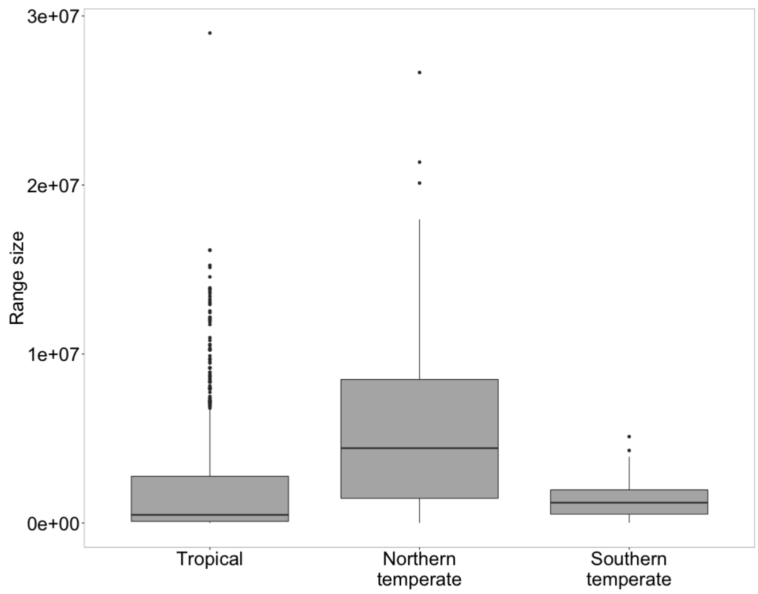


Figure B.3: Boxplot of range sizes in tropical, northern and southern temperate regions. Median range sizes are 4.8x10^5 km^2, 4.4x10^6 km^2 and 1.2x10^6 km^2, respectively. For each box, the central black line is the median, the edges of the box are 25th and 75th percentiles, the whiskers extend to the most extreme data points (vertical lines above or below the box), and outliers are plotted individually (dots).

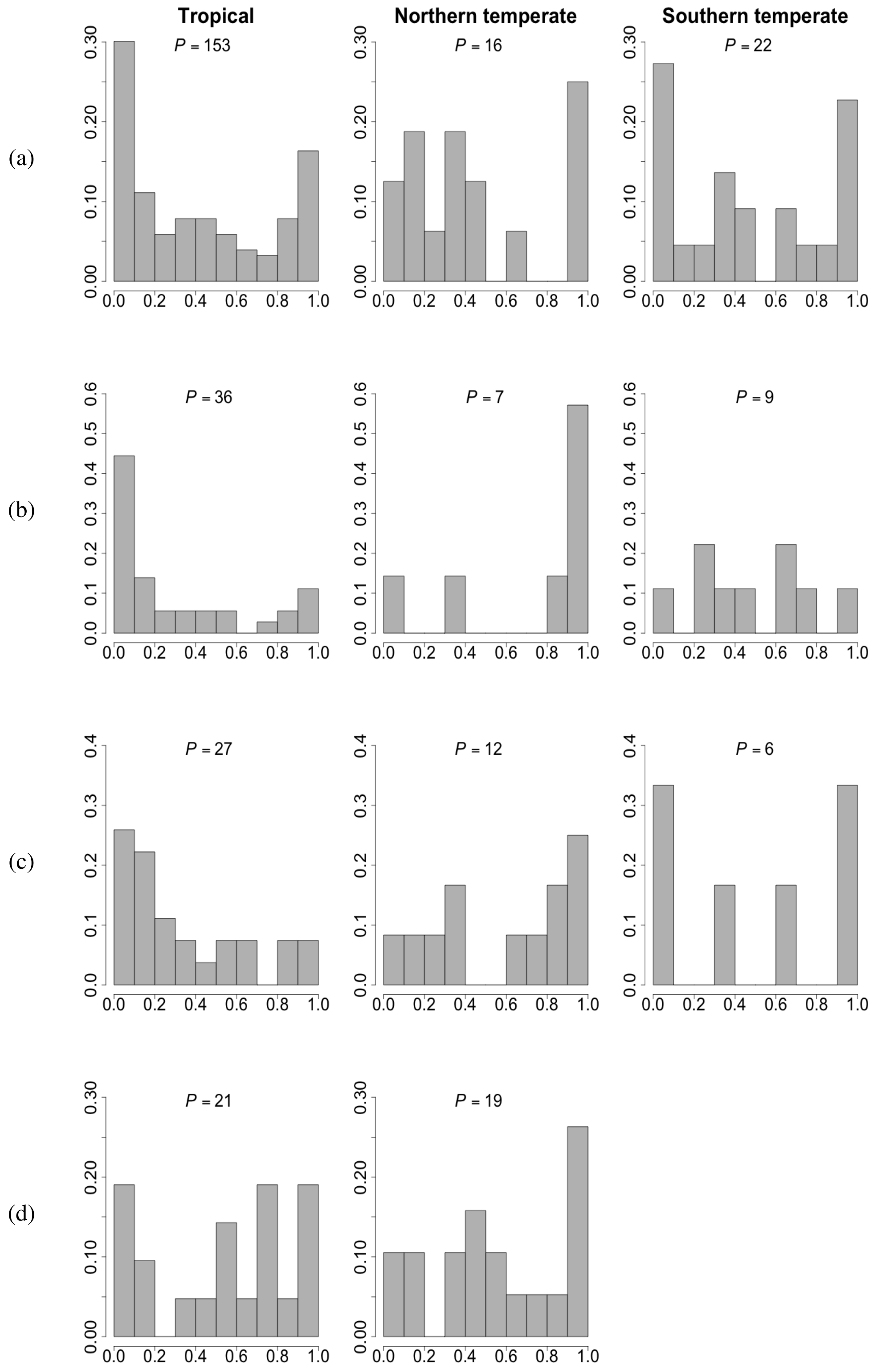


Figure B.4: The proportion of range overlap ratios in each region. Separated by the range sizes of the smaller species (a) $0–1.10^6$ km^2, (b) $1.10^6–2.10^6$ km^2, (c) $2.10^6–4.10^6$ km^2, and (d) $>4.10^6$ km^2. The number of pairs in each range interval are given by *P*. Note that Kruskal-Wallis Test, $p>0.05$ for all range size intervals, except for [$0–1.10^6$ km^2] range size interval.

APPENDIX C

ELEVATION

Species range sizes differ in different elevations (Hawkins and Diniz-Filho, 2006). Therefore, the distributions of range overlap ratio might show different patterns in the each elevation level of tropical, northern, southern temperate regions. GTOPO30 is a global digital elevation model (DEM) with a horizontal grid spacing of 30 arc seconds were used (U.S. Geological Survey, 1996). First, raster files that includes New World were divided into two categories with the values >1000 m as "highlands" and <1000 m as "lowlands" (Hawkins and Diniz-Filho, 2006) in ArcMap (ESRI, ArcMap 10.0). Then, we defined species according to range centroids as highland, or lowland species. We again excluded "mixed" sister pairs, which here refers to pairs that each species is found in different elevation.

Figure C.1 shows the number of sister pairs that are allopatric or sympatric in the lowlands and highlands of each region. An interesting observation is higher proportion of allopatric pairs in tropical highlands compared to all other regions (Also see Fig. C.2). This is probably due to the fact that tropical highland species are also the ones with the smallest range sizes (Fig. C.3). Species in the lowlands tend to have larger range sizes than highland species in each region (Mann-Whitney-Wilcoxon Test, $p < 0.05$ for tropical region; Mann-Whitney-Wilcoxon Test, $p > 0.05$ for northern and southern regions). Range overlap ratio distributions for lowlands give similar results with the range overlap ratios in Figure 3.3. Yet, there is no obvious trend in the tropical and northern temperate highlands (Fig. C.4). In the southern temperate highland, the range overlap ratio is close to one, but note that there is only one sympatric species in that region.

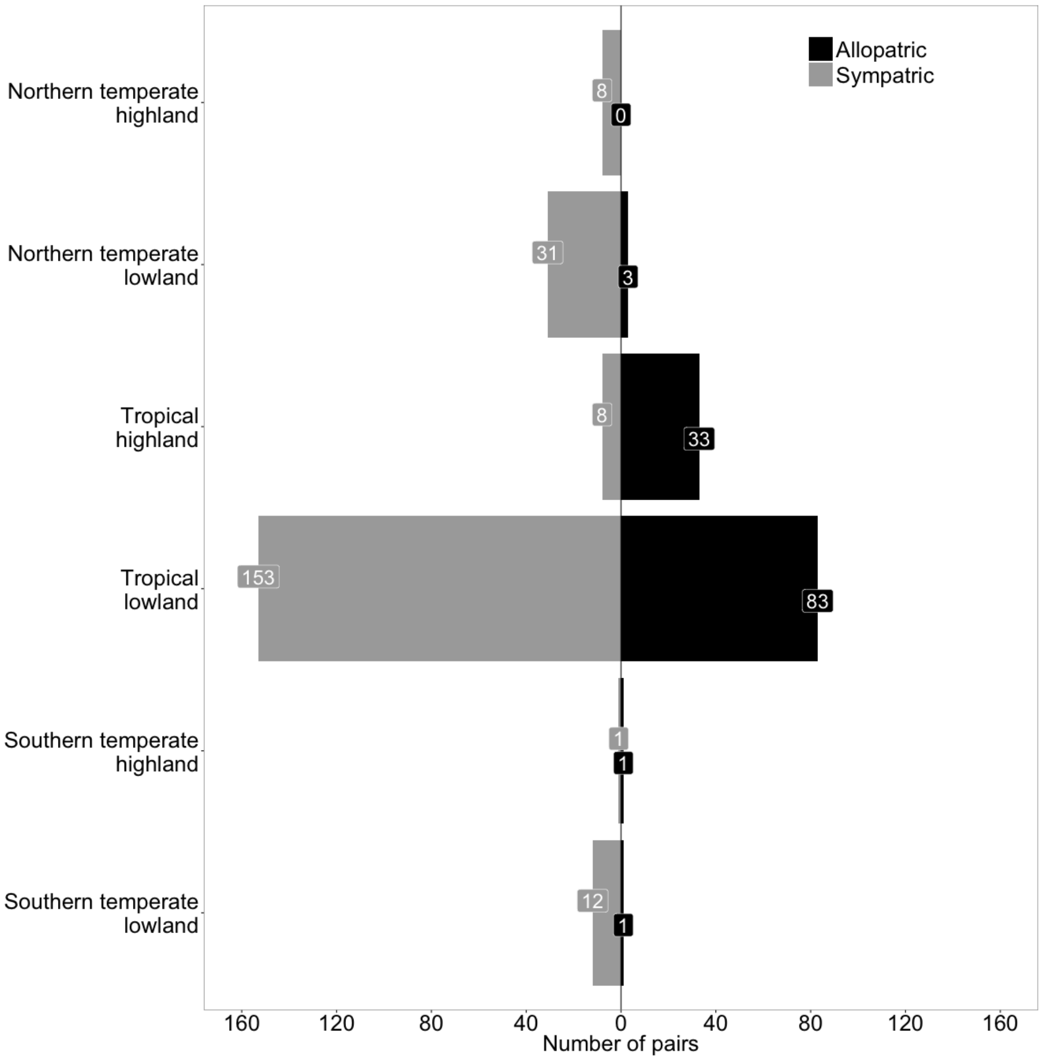
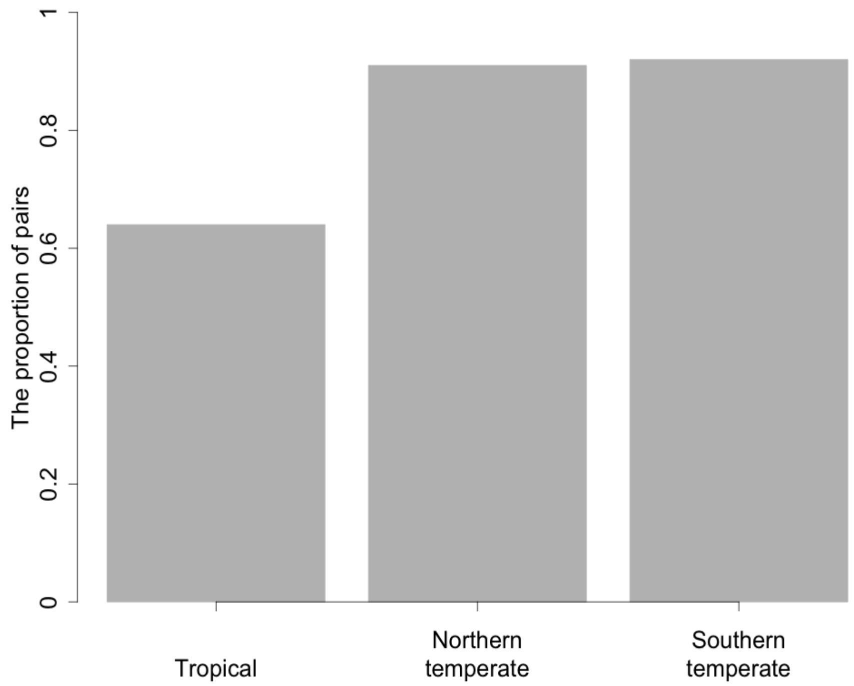


Figure C.1: The number of sister pairs that are sympatric or allopatric in the lowlands and highlands of each region.

(a)



(b)

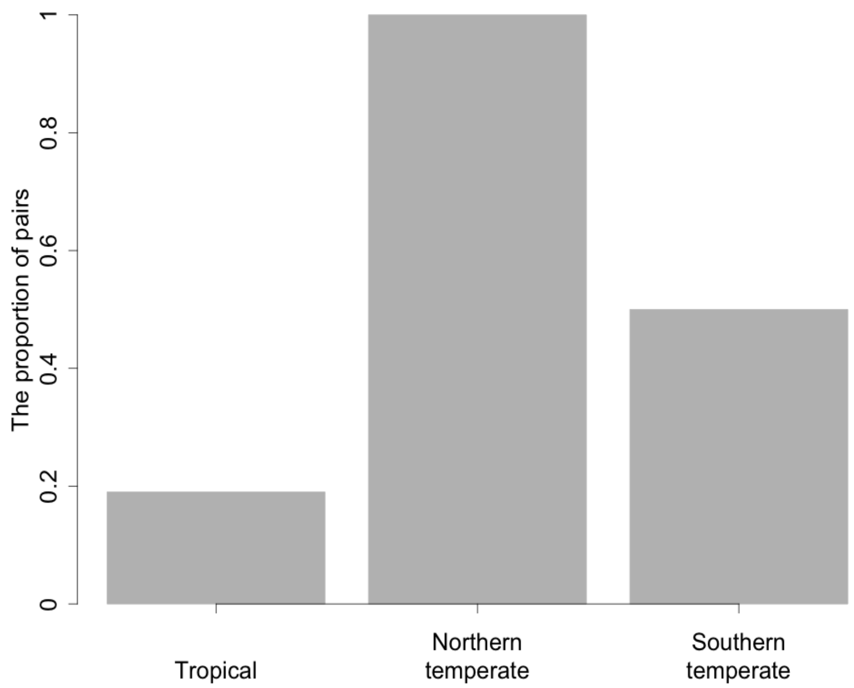


Figure C.2: The proportion of sister pairs that are sympatric (shown in gray) in the (a) lowlands and (b) highlands of tropical, northern and southern temperate regions.

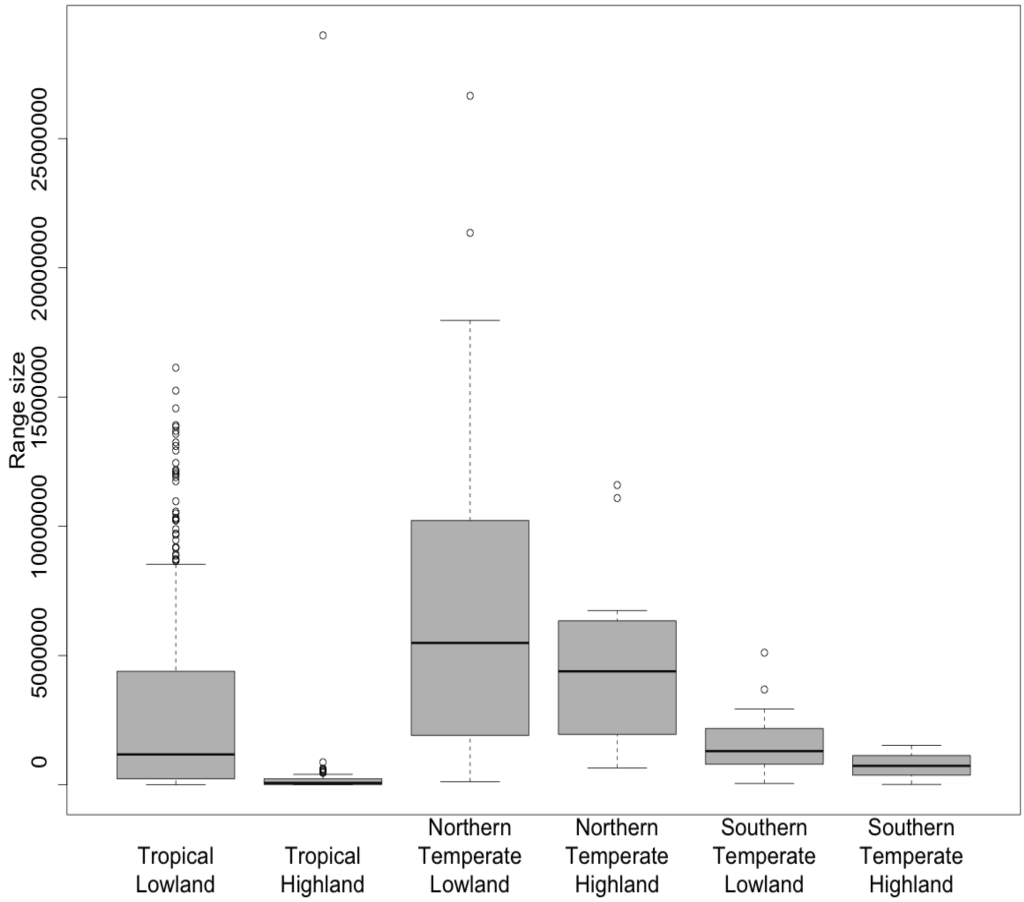


Figure C.3: Boxplot of species range sizes in the lowlands and highlands of tropical, northern and southern temperate regions.

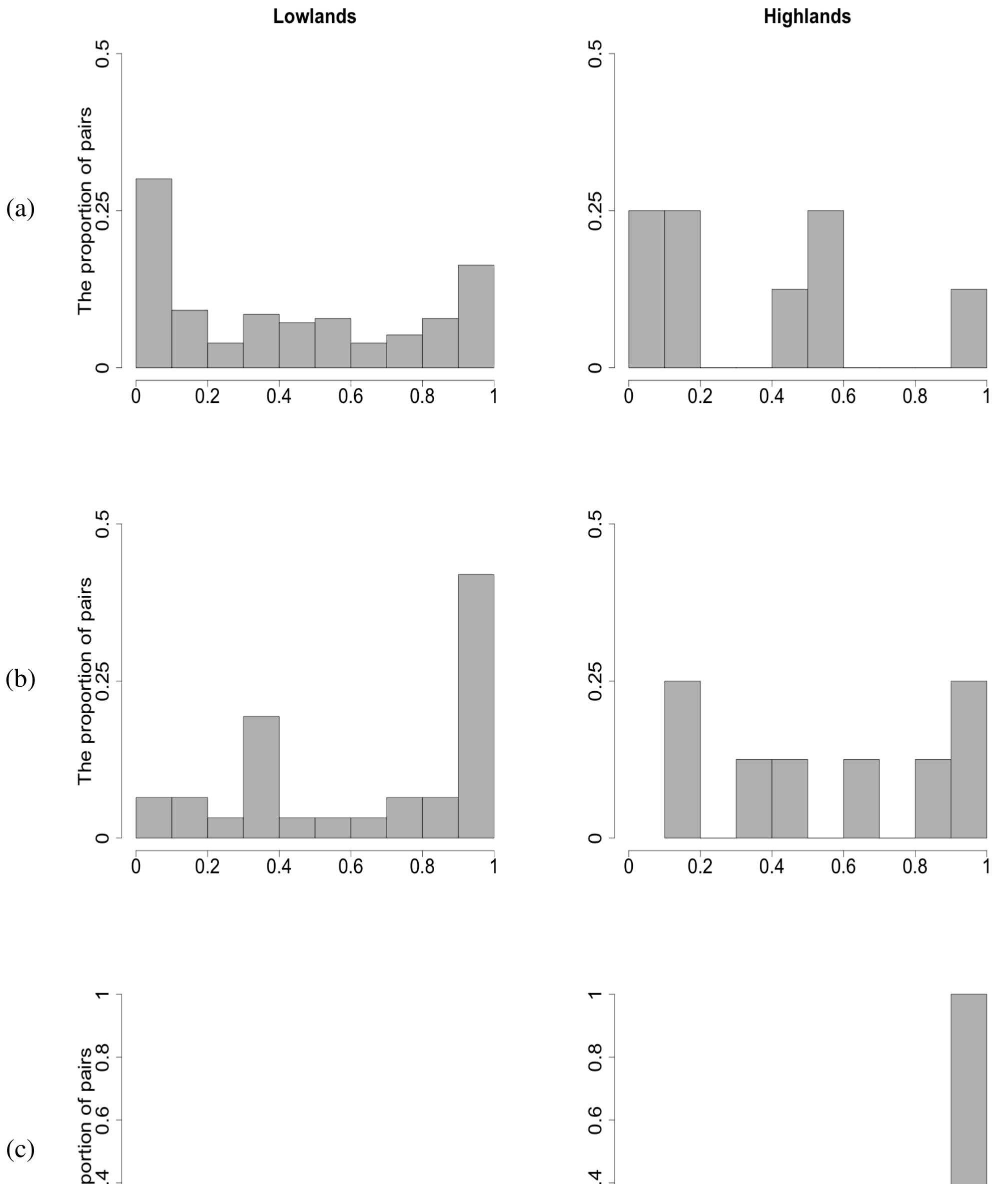


Figure C.4: The proportion of range overlap ratios of sympatric sister pairs in different regions for the lowlands and highlands of (a) tropical, (b) northern and (c) southern temperate regions. The proportion of species were calculated as sympatric pairs' range overlap ratio normalized by the total number of species pairs that are present in each region (P_{Tl}=153, P_{Th}=8, P_{NTl}=31, P_{NTh}=8, P_{STl}=12, and P_{STh}=1 respectively). Note that the value zero is not included since it refers to allopatric pairs.

APPENDIX D

SPECIES LIST

Table D.1: Species List

Species A	**Species B**	**Relatedness**	**Published study**
Campylorhamphus procurvoides	*Campylorhamphus trochilirostris*	Sister	Aleixo (2002)
Lepidocolaptes angustirostris	*Lepidocolaptes albolineatus*	Sister	Aleixo (2002)
Xiphorhynchus elegans	*Xiphorhynchus spixii*	Sister	Aleixo (2002)
Xiphorhynchus lachrymosus	*Xiphorhynchus flavigaster*	Sister	Aleixo (2002)
Xiphorhynchus ocellatus	*Xiphorhynchus pardalotus*	Sister	Aleixo (2002)
Xiphorhynchus susurrans	*Xiphorhynchus guttatus*	Sister	Aleixo (2002)
Phlegopsis nigromaculata	*Phlegopsis borbae*	Sister	Aleixo et al. (2009)
Phrygilus gayi	*Phrygilus atriceps*	Sister	Álvarez Varas et al. (2009)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Carduelis yarrellii	*Carduelis magellanica*	Sister	Aramaiz-Villena et al. (1998)
Pachyramphus polychopterus	*Pachyramphus albogriseus*	Sister	Barber and Rice (2007)
Tityra cayana	*Tityra semifasciata*	Sister	Barber and Rice (2007)
Iodopleura isabellae	*Iodopleura fusca*	Sister	Barber and Rice (2007)
Pachyramphus cinnamomeus	*Pachyramphus castaneus*	Sister	Barber and Rice (2007)
Pachyramphus homochrous	*Pachyramphus aglaiae*	Sister	Barber and Rice (2007)
Pachyramphus rufus	*Pachyramphus spodiurus*	Sister	Barber and Rice (2007)
Cistothorus platensis	*Cistothorus palustris*	Sister	Barker (2004)
Thryothorus guarayanus	*Thryothorus leucotis*	Sister	Barker (2004)
Campylorhynchus jocosus	*Campylorhynchus gularis*	Sister	Barker (2007)
Campylorhynchus chiapensis	*Campylorhynchus griseus*	Sister	Barker (2007)
Catamenia analis	*Catamenia inornata*	Most closely	Barker et al. (2015)
Piranga ludoviciana	*Piranga olivacea*	Most closely	Barker et al. (2015)
Sericossypha albocristata	*Nemosia pileata*	Most closely	Barker et al. (2015)
Sicalis flaveola	*Sicalis luteola*	Most closely	Barker et al. (2015)
Chlorospingus tacarcunae	*Chlorospingus semifuscus*	Most closely	Barker et al. (2015)
Aimophila ruficeps	*Aimophila notosticta*	Sister	Barker et al. (2015)
Ammodramus caudacutus	*Ammodramus nelsoni*	Sister	Barker et al. (2015)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Ammodramus humeralis	*Ammodramus aurifrons*	Sister	Barker et al. (2015)
Anisognathus igniventris	*Anisognathus lacrymosus*	Sister	Barker et al. (2015)
Arremonops rufivirgatus	*Arremonops chloronotus*	Sister	Barker et al. (2015)
Bangsia melanochlamys	*Bangsia rothschildi*	Sister	Barker et al. (2015)
Cacicus cela	*Cacicus uropygialis*	Sister	Barker et al. (2015)
Calcarius pictus	*Calcarius ornatus*	Sister	Barker et al. (2015)
Chlorospingus parvirostris	*Chlorospingus flavigularis*	Sister	Barker et al. (2015)
Chrysomus icterocephalus	*Chrysomus ruficapillus*	Sister	Barker et al. (2015)
Conirostrum margaritae	*Conirostrum bicolor*	Sister	Barker et al. (2015)
Conothraupis speculigera	*Volatinia jacarina*	Sister	Barker et al. (2015)
Coryphospingus cucullatus	*Coryphospingus pileatus*	Sister	Barker et al. (2015)
Cyanocompsa brissonii	*Cyanoloxia glaucocaerulea*	Sister	Barker et al. (2015)
Diglossa cyanea	*Diglossa caerulescens*	Sister	Barker et al. (2015)
Dubusia taeniata	*Delothraupis castaneoventris*	Sister	Barker et al. (2015)
Eucometis penicillata	*Trichothraupis melanops*	Sister	Barker et al. (2015)
Euphagus carolinus	*Euphagus cyanocephalus*	Sister	Barker et al. (2015)
Granatellus venustus	*Granatellus sallaei*	Sister	Barker et al. (2015)
Hemispingus frontalis	*Hemispingus melanotis*	Sister	Barker et al. (2015)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Icterus galbula	*Icterus abeillei*	Sister	Barker et al. (2015)
Icterus pustulatus	*Icterus bullockii*	Sister	Barker et al. (2015)
Iridophanes pulcherrimus	*Chlorophanes spiza*	Sister	Barker et al. (2015)
Iridosornis analis	*Iridosornis porphyrocephalus*	Sister	Barker et al. (2015)
Junco hyemalis	*Junco phaeonotus*	Sister	Barker et al. (2015)
Limnothlypis swainsonii	*Protonotaria citrea*	Sister	Barker et al. (2015)
Melanodera melanodera	*Melanodera xanthogramma*	Sister	Barker et al. (2015)
Melospiza georgiana	*Melospiza lincolnii*	Sister	Barker et al. (2015)
Oreopsar bolivianus	*Agelaioides badius*	Sister	Barker et al. (2015)
Passerina amoena	*Passerina caerulea*	Sister	Barker et al. (2015)
Passerina versicolor	*Passerina ciris*	Sister	Barker et al. (2015)
Phrygilus carbonarius	*Phrygilus alaudinus*	Sister	Barker et al. (2015)
Phrygilus unicolor	*Phrygilus plebejus*	Sister	Barker et al. (2015)
Pipilo erythrophthalmus	*Pipilo maculatus*	Sister	Barker et al. (2015)
Poospiza cinerea	*Poospiza melanoleuca*	Sister	Barker et al. (2015)
Psarocolius angustifrons	*Psarocolius atrovirens*	Sister	Barker et al. (2015)
Pseudoleistes guirahuro	*Pseudoleistes virescens*	Sister	Barker et al. (2015)
Quiscalus major	*Quiscalus mexicanus*	Sister	Barker et al. (2015)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Ramphocelus carbo	*Ramphocelus melanogaster*	Sister	Barker et al. (2015)
Saltator atricollis	*Saltatricula multicolor*	Sister	Barker et al. (2015)
Schistochlamys ruficapillus	*Schistochlamys melanopis*	Sister	Barker et al. (2015)
Sporophila nigricollis	*Sporophila caerulescens*	Sister	Barker et al. (2015)
Tachyphonus rufiventer	*Tachyphonus luctuosus*	Sister	Barker et al. (2015)
Tangara desmaresti	*Tangara cyanoventris*	Sister	Barker et al. (2015)
Tangara gyrola	*Tangara lavinia*	Sister	Barker et al. (2015)
Tangara icterocephala	*Tangara florida*	Sister	Barker et al. (2015)
Tangara velia	*Tangara callophrys*	Sister	Barker et al. (2015)
Thraupis ornata	*Thraupis palmarum*	Sister	Barker et al. (2015)
Thraupis sayaca	*Thraupis episcopus*	Sister	Barker et al. (2015)
Tiaris bicolor	*Melanospiza richardsoni*	Sister	Barker et al. (2015)
Tiaris obscurus	*Tiaris fuliginosus*	Sister	Barker et al. (2015)
Zonotrichia leucophrys	*Zonotrichia atricapilla*	Sister	Barker et al. (2015)
Zonotrichia querula	*Zonotrichia albicollis*	Sister	Barker et al. (2015)
Compsospiza baeri	*Compsospiza garleppi*	Sister	Barker et al. (2015)
Lophospingus pusillus	*Lophospingus griseocristatus*	Sister	Barker et al. (2015)
Tangara seledon	*Tangara fastuosa*	Sister	Barker et al. (2015)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Paroaria gularis	*Paroaria capitata*	Sister	Barker et al. (2015)
Poospiza boliviana	*Poospiza ornata*	Sister	Barker et al. (2015)
Sporophila schistacea	*Sporophila falcirostris*	Sister	Barker et al. (2015)
Agelasticus xanthophthalmus	*Agelasticus cyanopus*	Sister	Barker et al. (2015)
Bangsia aureocincta	*Bangsia edwardsi*	Sister	Barker et al. (2015)
Basileuterus belli	*Basileuterus melanogenys*	Sister	Barker et al. (2015)
Caryothraustes poliogaster	*Caryothraustes canadensis*	Sister	Barker et al. (2015)
Chlorochrysa nitidissima	*Chlorochrysa calliparaea*	Sister	Barker et al. (2015)
Chlorothraupis carmioli	*Chlorothraupis olivacea*	Sister	Barker et al. (2015)
Creurgops dentatus	*Creurgops verticalis*	Sister	Barker et al. (2015)
Cyanerpes lucidus	*Cyanerpes nitidus*	Sister	Barker et al. (2015)
Diglossa albilatera	*Diglossa venezuelensis*	Sister	Barker et al. (2015)
Diglossa gloriosissima	*Diglossa lafresnayii*	Sister	Barker et al. (2015)
Diglossa plumbea	*Diglossa baritula*	Sister	Barker et al. (2015)
Dives warszewiczi	*Dives dives*	Sister	Barker et al. (2015)
Hemispingus parodii	*Hemispingus calophrys*	Sister	Barker et al. (2015)
Hemispingus verticalis	*Hemispingus xanthophthalmus*	Sister	Barker et al. (2015)
Heterospingus xanthopygius	*Heterospingus rubrifrons*	Sister	Barker et al. (2015)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Icterus chrysater	*Icterus graduacauda*	Sister	Barker et al. (2015)
Icterus icterus	*Icterus jamacaii*	Sister	Barker et al. (2015)
Icterus nigrogularis	*Icterus gularis*	Sister	Barker et al. (2015)
Icterus pectoralis	*Icterus graceannae*	Sister	Barker et al. (2015)
Iridosornis reinhardti	*Iridosornis rufivertex*	Sister	Barker et al. (2015)
Lanio aurantius	*Lanio leucothorax*	Sister	Barker et al. (2015)
Macroagelaius imthurni	*Macroagelaius subalaris*	Sister	Barker et al. (2015)
Myioborus cardonai	*Myioborus castaneocapilla*	Sister	Barker et al. (2015)
Myioborus melanocephalus	*Myioborus ornatus*	Sister	Barker et al. (2015)
Pselliophorus tibialis	*Pselliophorus luteoviridis*	Sister	Barker et al. (2015)
Quiscalus lugubris	*Quiscalus nicaraguensis*	Sister	Barker et al. (2015)
Ramphocelus dimidiatus	*Ramphocelus nigrogularis*	Sister	Barker et al. (2015)
Ramphocelus passerinii	*Ramphocelus costaricensis*	Sister	Barker et al. (2015)
Rhodothraupis celaeno	*Periporphyrus erythromelas*	Sister	Barker et al. (2015)
Saltator atripennis	*Saltator atriceps*	Sister	Barker et al. (2015)
Tangara cucullata	*Tangara cayana*	Sister	Barker et al. (2015)
Tangara dowii	*Tangara fucosa*	Sister	Barker et al. (2015)
Tangara mexicana	*Tangara inornata*	Sister	Barker et al. (2015)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Tangara heinei	*Tangara argyrofenges*	Sister/most	Barker et al. (2015)
Drymophila devillei	*Drymophila caudata*	Sister	Bates et al. (1999)
Formicivora grisea	*Formicivora rufa*	Sister	Bates et al. (1999)
Procnias nudicollis	*Procnias albus*	Closely	Berv and Prum (2014)
Xipholena atropurpurea	*Xipholena punicea*	Most closely	Berv and Prum (2014)
Ampelion rufaxilla	*Ampelion rubrocristatus*	Sister	Berv and Prum (2014)
Cephalopterus ornatus	*Perissocephalus tricolor*	Sister	Berv and Prum (2014)
Conioptilon mcilhennyi	*Gymnoderus foetidus*	Sister	Berv and Prum (2014)
Lipaugus vociferans	*Lipaugus streptophorus*	Sister	Berv and Prum (2014)
Pipreola chlorolepidota	*Pipreola frontalis*	Sister	Berv and Prum (2014)
Snowornis subalaris	*Snowornis cryptolophus*	Sister	Berv and Prum (2014)
Rupicola rupicola	*Rupicola peruvianus*	Sister	Berv and Prum (2014)
Cyanolyca argentigula	*Cyanolyca pumilo*	Sister	Bonaccorso (2009)
Cyanolyca cucullata	*Cyanolyca pulchra*	Sister	Bonaccorso (2009)
Cyanolyca mirabilis	*Cyanolyca nana*	Sister	Bonaccorso (2009)
Cyanolyca viridicyanus	*Cyanolyca turcosa*	Sister	Bonaccorso (2009)
Cyanocorax chrysops	*Cyanocorax cyanopogon*	Sister	Bonaccorso et al. (2010)
Cyanocorax cyanomelas	*Cyanocorax cristatellus*	Sister	Bonaccorso et al. (2010)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Cyanocorax sanblasianus	*Cyanocorax beecheii*	Sister	Bonaccorso et al. (2010)
Cyanocorax affinis	*Cyanocorax heilprini*	Sister	Bonaccorso et al. (2010)
Calocitta colliei	*Calocitta formosa*	Sister	Bonaccorso and Peterson (2007)
Pseudotriccus ruficeps	*Pseudotriccus simplex*	Most closely	Boyle (2006)
Pseudelaenia leucospodia	*Stigmatura napensis*	Most closely	Boyle (2006)
Hemitriccus zosterops	*Hemitriccus griseipectus*	Sister	Boyle (2006)
Ramphotrigon fuscicauda	*Ramphotrigon ruficauda*	Sister	Boyle (2006)
Rhynchocyclus brevirostris	*Rhynchocyclus olivaceus*	Sister	Boyle (2006)
Polystictus pectoralis	*Polystictus superciliaris*	Sister	Boyle (2006)
Myrmeciza pelzelni	*Myrmeciza atrothorax*	Sister	Bravo et al. (2012b)
Thamnomanes caesius	*Thamnomanes schistogynus*	Sister	Bravo et al. (2012b)
Thamnomanes saturninus	*Thamnomanes ardesiacus*	Sister	Bravo et al. (2012b)
Myrmeciza immaculata	*Myrmeciza fortis*	Sister	Bravo et al. (2012b)
Terenura sharpei	*Terenura callinota*	Sister	Bravo et al. (2012a)
Manacus manacus	*Manacus vitellinus*	Sister	Brumfield and Braun (2001)
Manacus aurantiacus	*Manacus candei*	Sister	Brumfield and Braun (2001)
Thamnophilus aroyae	*Thamnophilus aethiops*	Sister	Brumfield and Edwards (2007)
Thamnophilus murinus	*Thamnophilus schistaceus*	Sister	Brumfield and Edwards (2007)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Sakesphorus luctuosus	*Sakesphorus canadensis*	Sister	Brumfield and Edwards (2007)
Thamnophilus cryptoleucus	*Thamnophilus nigrocinereus*	Sister	Brumfield et al. (2007)
Thamnophilus ruficapillus	*Thamnophilus torquatus*	Sister	Brumfield et al. (2007)
Thamnophilus stictocephalus	*Thamnophilus punctatus*	Sister	Brumfield et al. (2007)
Thamnophilus atrinucha	*Thamnophilus bridgesi*	Sister	Brumfield et al. (2007)
Thamnophilus nigriceps	*Thamnophilus praecox*	Sister	Brumfield et al. (2007)
Thamnophilus tenuepunctatus	*Thamnophilus palliatus*	Sister	Brumfield et al. (2007)
Dysithamnus mentalis	*Dysithamnus plumbeus*	Sister	Brumfield et al. (2007)
Myrmeciza goeldii	*Myrmeciza melanoceps*	Sister	Brumfield et al. (2007)
Pithys albifrons	*Pithys castaneus*	Sister	Brumfield et al. (2007)
Rhegmatorhina gymnops	*Rhegmatorhina hoffmannsi*	Sister	Brumfield et al. (2007)
Piranga leucoptera	*Piranga rubriceps*	Sister	Burns (1998)
Tiaris olivaceus	*Coereba flaveola*	Sister	Burns et al. (2002)
Sporophila melanogaster	*Sporophila cinnamomea*	Sister	Burns et al. (2014)
Tachyphonus coronatus	*Tachyphonus rufus*	Sister	Burns et al. (2014)
Oryzoborus angolensis	*Oryzoborus funereus*	Sister	Burns et al. (2014)
Tangara larvata	*Tangara cyanicollis*	Sister	Burns and Naoki (2004)
Tangara punctata	*Tangara xanthogastra*	Sister	Burns and Naoki (2004)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Hypopyrrhus pyrohypogaster	*Lampropsar tanagrinus*	Sister	Cadena et al. (2004)
Idiopsar brachyurus	*Phrygilus dorsalis*	Most closely	Campagna et al. (2011)
Conirostrum sitticolor	*Oreomanes fraseri*	Sister	Campagna et al. (2011)
Emberizoides herbicola	*Emberizoides ypiranganus*	Sister	Campagna et al. (2011)
Passerella iliaca	*Spizella arborea*	Sister	Carson and Spicer (2003)
Pooecetes gramineus	*Amphispiza belli*	Sister	Carson and Spicer (2003)
Attila phoenicurus	*Attila rufus*	Sister	Chaves et al. (2008)
Myiobius atricaudus	*Myiobius barbatus*	Sister	Chaves et al. (2008)
Poecilotriccus plumbeiceps	*Poecilotriccus latirostris*	Sister	Chaves et al. (2008)
Saltator albicollis	*Saltator similis*	Sister	Chaves et al. (2013)
Muscisaxicola capistratus	*Muscisaxicola frontalis*	Sister	Chesser (2000)
Muscisaxicola flavinucha	*Muscisaxicola cinereus*	Sister	Chesser (2000)
Pteroptochos castaneus	*Pteroptochos tarnii*	Sister	Chesser (2000)
Cinclodes fuscus	*Cinclodes antarcticus*	Sister	Chesser (2004)
Cinclodes palliatus	*Cinclodes atacamensis*	Sister	Chesser (2004)
Cinclodes oustaleti	*Cinclodes olrogi*	Sister	Chesser (2004)
Cinclodes taczanowskii	*Cinclodes nigrofumosus*	Sister	Chesser (2004)
Cinclodes aricomae	*Cinclodes excelsior*	Sister	Chesser (2004)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Upucerthia albigula	*Upucerthia dumetaria*	Sister	Chesser et al. (2007)
Geositta cunicularia	*Geositta tenuirostris*	Sister	Cheviron et al. (2005)
Geositta punensis	*Geositta rufipennis*	Sister	Cheviron et al. (2005)
Geositta saxicolina	*Geositta isabellina*	Sister	Cheviron et al. (2005)
Geositta poeciloptera	*Geositta crassirostris*	Sister	Cheviron et al. (2005)
Drymornis bridgesii	*Drymotoxeres pucherani*	Sister	Claramunt et al. (2010)
Automolus rufipileatus	*Automolus melanopezus*	Sister	Claramunt et al. (2013)
Automolus rubiginosus	*Hylocryptus erythrocephalus*	Sister	Claramunt et al. (2013)
Lepidocolaptes affinis	*Lepidocolaptes lacrymiger*	Most closely	Arbeláez-Cortés et al. (2010)
Amphispiza bilineata	*Amphispiza quinquestriata*	Sister	DaCosta et al. (2009)
Spizella passerina	*Spizella pallida*	Sister	DaCosta et al. (2009)
Arremon aurantiirostris	*Arremon flavirostris*	Sister	DaCosta et al. (2009)
Asthenes dorbignyi	*Asthenes baeri*	Sister	Derryberry et al. (2010)
Asthenes modesta	*Asthenes humilis*	Sister	Derryberry et al. (2010)
Asthenes sclateri	*Asthenes wyatti*	Sister	Derryberry et al. (2010)
Liosceles thoracicus	*Psilorhamphus guttatus*	Sister	Ericson et al. (2010)
Rhinocrypta lanceolata	*Acropternis orthonyx*	Sister	Ericson et al. (2010)
Scytalopus superciliaris	*Scytalopus zimmeri*	Sister	Ericson et al. (2010)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Hylophylax naevioides	*Hylophylax naevius*	Sister	Fernandes et al. (2014)
Cranioleuca henricae	*Cranioleuca obsoleta*	Sister	García-Moreno et al. (1999)
Cranioleuca albiceps	*Cranioleuca marcapatae*	Sister	García-Moreno et al. (1999)
Cranioleuca curtata	*Cranioleuca antisiensis*	Sister	García-Moreno et al. (1999)
Parus atricapillus	*Parus gambeli*	Sister	Gill et al. (2005)
Parus rufescens	*Parus hudsonicus*	Sister	Gill et al. (2005)
Parus sclateri	*Parus carolinensis*	Sister	Gill et al. (2005)
Leptasthenura aegithaloides	*Leptasthenura fuliginiceps*	Sister	Gonzalez (2014)
Gymnopithys leucaspis	*Gymnopithys rufigula*	Sister	Hackett (1993)
Gymnopithys lunulatus	*Gymnopithys salvini*	Sister	Hackett (1993)
Myrmotherula behni	*Myrmotherula grisea*	Sister	Hackett and Rosenberg (1990)
Corvus brachyrhynchos	*Corvus caurinus*	Sister	Haring et al. (2012)
Empidonax wrightii	*Empidonax minimus*	Sister	Heller et al. (2016)
Knipolegus nigerrimus	*Knipolegus lophotes*	Sister	Hosner and Moyle (2012)
Mimus gilvus	*Mimus polyglottos*	Sister	Hunt et al. (2001)
Batara cinerea	*Hypoedaleus guttatus*	Sister	Irestedt et al. (2004)
Pygiptila stellaris	*Thamnistes anabatinus*	Sister	Irestedt et al. (2004)
Anumbius annumbi	*Coryphistera alaudina*	Sister	Irestedt et al. (2009)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Certhiaxis cinnamomeus	*Schoeniophylax phryganophilus*	Sister	Irestedt et al. (2009)
Cranioleuca sulphurifera	*Limnoctites rectirostris*	Sister	Irestedt et al. (2009)
Nasica longirostris	*Dendrexetastes rufigula*	Sister	Irestedt et al. (2009)
Ochetorhynchus phoenicurus	*Ochetorhynchus ruficaudus*	Sister	Irestedt et al. (2009)
Phleocryptes melanops	*Limnornis curvirostris*	Sister	Irestedt et al. (2009)
Pseudoseisura lophotes	*Spartonoica maluroides*	Sister	Irestedt et al. (2009)
Sittasomus griseicapillus	*Deconychura longicauda*	Sister	Irestedt et al. (2009)
Synallaxis scutata	*Synallaxis ruficapilla*	Sister	Irestedt et al. (2009)
Syndactyla rufosuperciliata	*Simoxenops ucayalae*	Sister	Irestedt et al. (2009)
Upucerthia jelskii	*Upucerthia validirostris*	Sister	Irestedt et al. (2009)
Xenops minutus	*Xenops rutilans*	Sister	Irestedt et al. (2009)
Xiphocolaptes promeropirhynchus	*Xiphocolaptes major*	Sister	Irestedt et al. (2009)
Xiphorhynchus erythropygius	*Xiphorhynchus triangularis*	Sister	Irestedt et al. (2009)
Leptasthenura yanacensis	*Sylviorthorhynchus desmursii*	Sister	Irestedt et al. (2009)
Tarphonomus harterti	*Tarphonomus certhioides*	Sister	Irestedt et al. (2009)
Schistocichla leucostigma	*Myrmeciza hyperythra*	Closely	Isler et al. (2013)
Myrmoborus leucophrys	*Myrmoborus myotherinus*	Most closely	Isler et al. (2013)
Myrmeciza laemosticta	*Myrmeciza nigricauda*	Most closely	Isler et al. (2013)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Myrmeciza hemimelaena	*Myrmeciza castanea*	Sister	Isler et al. (2013)
Myrmeciza loricata	*Myrmeciza squamosa*	Sister	Isler et al. (2013)
Pyriglena leucoptera	*Pyriglena leuconota*	Sister	Isler et al. (2013)
Schistocichla saturata	*Schistocichla schistacea*	Sister	Isler et al. (2013)
Fluvicola albiventer	*Fluvicola pica*	Sister	Johansson et al. (2002)
Baeolophus bicolor	*Baeolophus atricristatus*	Sister	Johansson et al. (2013)
Baeolophus ridgwayi	*Baeolophus inornatus*	Sister	Johansson et al. (2013)
Empidonax oberholseri	*Empidonax affinis*	Sister	Johnson and Cicero (2002)
Empidonax occidentalis	*Empidonax difficilis*	Sister	Johnson and Cicero (2002)
Empidonax fulvifrons	*Empidonax atriceps*	Sister	Johnson and Cicero (2002)
Myiarchus swainsoni	*Myiarchus tuberculifer*	Sister	Joseph et al. (2004)
Sialia currucoides	*Sialia mexicana*	Most closely	Klicka et al. (2005)
Catharus aurantiirostris	*Catharus mexicanus*	Sister	Klicka et al. (2005)
Catharus dryas	*Catharus fuscater*	Sister	Klicka et al. (2005)
Entomodestes leucotis	*Entomodestes coracinus*	Sister	Klicka et al. (2005)
Pheucticus melanocephalus	*Pheucticus ludovicianus*	Sister	Klicka et al. (2007b)
Habia gutturalis	*Habia fuscicauda*	Sister	Klicka et al. (2007b)
Mitrospingus oleagineus	*Mitrospingus cassinii*	Sister	Klicka et al. (2007b)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Ammodramus henslowii	*Ammodramus bairdii*	Sister	Klicka et al. (2007a)
Scytalopus affinis	*Scytalopus canus*	Sister	Krabbe and Cadena (2010)
Agelaius tricolor	*Agelaius phoeniceus*	Sister	Lanyon (1994)
Aphanotriccus audax	*Lathrotriccus euleri*	Sister	Lanyon and Lanyon (1986)
Molothrus bonariensis	*Molothrus ater*	Sister	Lanyon and Omland (1999)
Sturnella neglecta	*Sturnella magna*	Sister	Lanyon and Omland (1999)
Xanthocephalus xanthocephalus	*Dolichonyx oryzivorus*	Sister	Lanyon and Omland (1999)
Sturnella militaris	*Sturnella bellicosa*	Sister	Lanyon and Omland (1999)
Sporophila ruficollis	*Sporophila hypochroma*	Sister	Lijtmaer et al. (2004)
Sporophila telasco	*Sporophila castaneiventris*	Sister	Lijtmaer et al. (2004)
Dendroica caerulescens	*Setophaga ruticilla*	Sister	Lovette and Bermingham (1999)
Dendroica graciae	*Dendroica nigrescens*	Sister	Lovette and Bermingham (1999)
Dendroica occidentalis	*Dendroica townsendi*	Sister	Lovette and Bermingham (1999)
Dendroica pinus	*Dendroica pityophila*	Sister	Lovette and Bermingham (1999)
Basileuterus culicivorus	*Basileuterus hypoleucus*	Sister	Lovette et al. (2010)
Basileuterus flaveolus	*Basileuterus leucoblepharus*	Sister	Lovette et al. (2010)
Dendroica virens	*Dendroica chrysoparia*	Sister	Lovette et al. (2010)
Geothlypis aequinoctialis	*Geothlypis poliocephala*	Sister	Lovette et al. (2010)

Table D.1: (continued)

Species A	Species B	Relatedness	Published study
Geothlypis flavovelata	*Geothlypis nelsoni*	Sister	Lovette et al. (2010)
Oporornis tolmiei	*Oporornis philadelphia*	Sister	Lovette et al. (2010)
Parula pitiayumi	*Parula americana*	Sister	Lovette et al. (2010)
Vermivora chrysoptera	*Vermivora cyanoptera*	Sister	Lovette et al. (2010)
Vermivora luciae	*Vermivora virginiae*	Sister	Lovette et al. (2010)
Basileuterus cinereicollis	*Basileuterus conspicillatus*	Sister	Lovette et al. (2010)
Basileuterus trifasciatus	*Basileuterus tristriatus*	Sister	Lovette et al. (2010)
Ergaticus ruber	*Ergaticus versicolor*	Sister	Lovette et al. (2010)
Parula superciliosa	*Parula gutturalis*	Sister	Lovette et al. (2010)
Mimus triurus	*Mimus dorsalis*	Sister	Lovette et al. (2012)
Mimus thenca	*Mimus patagonicus*	Sister	Lovette and Rubenstein (2007)
Melanotis hypoleucus	*Melanotis caerulescens*	Sister	Lovette and Rubenstein (2007)
Thryothorus pleurostictus	*Thryothorus sinaloa*	Sister	Mann et al. (2006)
Hylorchilus sumichrasti	*Catherpes mexicanus*	Sister	Mann et al. (2006)
Cyphorhinus arada	*Uropsila leucogastra*	Sister	Mann et al. (2006)
Thryothorus leucopogon	*Thryothorus thoracicus*	Sister	Mann et al. (2006)
Thryothorus nigricapillus	*Thryothorus semibadius*	Sister	Mann et al. (2006)
Thryothorus rutilus	*Thryothorus maculipectus*	Sister	Mann et al. (2006)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Thryothorus sclateri	*Thryothorus felix*	Sister	Mann et al. (2006)
Troglodytes rufulus	*Troglodytes ochraceus*	Most closely	Martínez Goméz et al. (2005)
Troglodytes sissonii	*Troglodytes aedon*	Most closely	Martínez Goméz et al. (2005)
Sporophila collaris	*Sporophila plumbea*	Most closely	Mason and Burns (2013)
Scytalopus speluncae	*Scytalopus novacapitalis*	Sister	Mata et al. (2009)
Eleoscytalopus indigoticus	*Eleoscytalopus psychopompus*	Sister	Mata et al. (2009)
Aphelocoma unicolor	*Aphelocoma ultramarina*	Sister	McCormack et al. (2008)
Aphelocoma californica	*Aphelocoma insularis*	Sister	McCormack et al. (2010)
Myadestes unicolor	*Myadestes occidentalis*	Sister	Miller et al. (2007)
Myadestes melanops	*Myadestes coloratus*	Sister	Miller et al. (2007)
Mionectes oleagineus	*Mionectes macconnelli*	Sister	Miller et al. (2008)
Mionectes olivaceus	*Mionectes striaticollis*	Sister	Miller et al. (2008)
Hirundinea ferruginea	*Pyrrhomyias cinnamomeus*	Sister	Mobley and Prum (1995)
Xenerpestes singularis	*Metopothrix aurantiaca*	Sister	Moyle et al. (2009)
Turdus serranus	*Turdus fuscater*	Most closely	Nylander et al. (2008)
Turdus flavipes	*Turdus lawrencii*	Sister	Nylander et al. (2008)
Turdus fumigatus	*Turdus hauxwelli*	Sister	Nylander et al. (2008)
Turdus rufitorques	*Turdus migratorius*	Sister	Nylander et al. (2008)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Turdus assimilis	*Turdus albicollis*	Sister	Nylander et al. (2008)
Turdus ignobilis	*Turdus maranonicus*	Sister	Nylander et al. (2008)
Turdus infuscatus	*Turdus nigrescens*	Sister	Nylander et al. (2008)
Turdus jamaicensis	*Turdus swalesi*	Sister	Nylander et al. (2008)
Turdus nudigenis	*Turdus haplochrous*	Sister	Nylander et al. (2008)
Cotinga cayana	*Cotinga maynana*	Sister	Ohlson et al. (2007)
Polioxolmis rufipennis	*Cnemarchus erythropygius*	Sister	Ohlson et al. (2008)
Attila spadiceus	*Attila torridus*	Sister	Ohlson et al. (2008)
Casiornis rufus	*Rhytipterna simplex*	Sister	Ohlson et al. (2008)
Gubernetes yetapa	*Alectrurus risora*	Sister	Ohlson et al. (2008)
Laniisoma elegans	*Laniocera hypopyrra*	Sister	Ohlson et al. (2008)
Myiophobus fasciatus	*Myiophobus cryptoxanthus*	Sister	Ohlson et al. (2008)
Myiophobus roraimae	*Myiophobus flavicans*	Sister	Ohlson et al. (2008)
Piprites pileata	*Piprites chloris*	Sister	Ohlson et al. (2008)
Schiffornis turdina	*Schiffornis virescens*	Sister	Ohlson et al. (2008)
Phyllomyias fasciatus	*Phyllomyias griseiceps*	Sister	Ohlson et al. (2008)
Neopelma sulphureiventer	*Neopelma pallescens*	Most closely	Ohlson et al. (2013)
Corapipo gutturalis	*Corapipo altera*	Most closely	Ohlson et al. (2013)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Pipra erythrocephala	*Pipra mentalis*	Sister	Ohlson et al. (2013)
Tyranneutes stolzmanni	*Tyranneutes virescens*	Sister	Ohlson et al. (2013)
Xenopipo atronitens	*Xenopipo uniformis*	Sister	Ohlson et al. (2013)
Catharus fuscescens	*Catharus minimus*	Sister	Outlaw et al. (2003)
Catharus guttatus	*Catharus occidentalis*	Sister	Outlaw et al. (2003)
Margarornis bellulus	*Margarornis squamiger*	Sister	Price and Lanyon (2010)
Premnoplex brunnescens	*Premnoplex tatei*	Sister	Price and Lanyon (2010)
Ocyalus latirostris	*Clypicterus oseryi*	Sister	Price and Lanyon (2002)
Psarocolius bifasciatus	*Psarocolius montezuma*	Sister	Price and Lanyon (2002)
Cacicus sclateri	*Cacicus chrysopterus*	Sister	Price and Lanyon (2003)
Heterocercus linteatus	*Heterocercus flavivertex*	Sister	Prum (1997)
Pipra aureola	*Pipra fasciicauda*	Sister	Prum (1997)
Lepidothrix serena	*Lepidothrix suavissima*	Sister	Prum (1997)
Machaeropterus regulus	*Machaeropterus pyrocephalus*	Sister	Prum (1998)
Dendrocolaptes picumnus	*Dendrocolaptes platyrostris*	Sister	Raikow (1994)
Serpophaga munda	*Serpophaga subcristata*	Sister	Rheindt et al. (2007)
Sublegatus obscurior	*Sublegatus arenarum*	Sister	Rheindt et al. (2007)
Serpophaga cinerea	*Serpophaga nigricans*	Sister	Rheindt et al. (2007)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Elaenia flavogaster	*Elaenia parvirostris*	Sister	Rheindt et al. (2008)
Elaenia mesoleuca	*Elaenia chiriquensis*	Sister	Rheindt et al. (2008)
Elaenia pelzelni	*Elaenia spectabilis*	Sister	Rheindt et al. (2008)
Elaenia ruficeps	*Elaenia cristata*	Sister	Rheindt et al. (2008)
Elaenia dayi	*Elaenia obscura*	Sister	Rheindt et al. (2008)
Zimmerius albigularis	*Zimmerius vilissimus*	Sister	Rheindt et al. (2008)
Zimmerius viridiflavus	*Zimmerius chrysops*	Sister	Rheindt et al. (2008)
Hemitriccus minimus	*Myiornis ecaudatus*	Sister	Rheindt et al. (2008)
Elaenia albiceps	*Elaenia frantzii*	Sister	Rheindt et al. (2009)
Myiopagis olallai	*Myiopagis caniceps*	Sister	Rheindt et al. (2009)
Myiopagis gaimardii	*Myiopagis subplacens*	Sister	Rheindt et al. (2009)
Grallaria dignissima	*Grallaria eludens*	Sister	H (2005)
Grallaria ruficapilla	*Grallaria watkinsi*	Sister	H (2005)
Grallaria rufula	*Grallaria blakei*	Sister	H (2005)
Myrmothera campanisona	*Myrmothera simplex*	Sister	H (2005)
Pittasoma rufopileatum	*Pittasoma michleri*	Sister	H (2005)
Anairetes flavirostris	*Anairetes alpinus*	Sister	Roy et al. (1999)
Anairetes reguloides	*Anairetes nigrocristatus*	Sister	Roy et al. (1999)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Atlapetes fulviceps	*Atlapetes citrinellus*	Sister	Sánchez-González et al. (2015)
Myiarchus crinitus	*Myiarchus cinerascens*	Sister	Sari and Parker (2012)
Cyanocitta stelleri	*Cyanocitta cristata*	Sister	Saunders and Edwards (2000)
Thraupis bonariensis	*Pipraeidea melanonota*	Sister	Sedano and Burns (2010)
Thraupis cyanocephala	*Buthraupis wetmorei*	Sister	Sedano and Burns (2010)
Buthraupis aureodorsalis	*Buthraupis eximia*	Sister	Sedano and Burns (2010)
Atticora melanoleuca	*Pygochelidon cyanoleuca*	Sister	Sheldon et al. (2005)
Haplochelidon andecola	*Notiochelidon murina*	Sister	Sheldon et al. (2005)
Stelgidopteryx serripennis	*Stelgidopteryx ruficollis*	Sister	Sheldon et al. (2005)
Tachycineta leucorrhoa	*Tachycineta meyeni*	Sister	Sheldon et al. (2005)
Neochelidon tibialis	*Notiochelidon pileata*	Sister	Sheldon et al. (2005)
Tachycineta albiventer	*Tachycineta albilinea*	Sister	Sheldon et al. (2005)
Hemispingus trifasciatus	*Poospiza torquata*	Sister	Shultz and Burns (2013)
Oncostoma cinereigulare	*Lophotriccus pileatus*	Sister	Tello and Bates (2007)
Poecilotriccus albifacies	*Poecilotriccus capitalis*	Sister	Tello and Bates (2007)
Ochthoeca oenanthoides	*Ochthoeca cinnamomeiventris*	Most closely	Tello et al. (2009)
Empidonomus aurantioatrocristatus	*Empidonomus varius*	Sister	Tello et al. (2009)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Euscarthmus meloryphus	*Euscarthmus rufomarginatus*	Sister	Tello et al. (2009)
Inezia subflava	*Inezia inornata*	Sister	Tello et al. (2009)
Myiodynastes maculatus	*Myiodynastes luteiventris*	Sister	Tello et al. (2009)
Myiopagis flavivertex	*Myiopagis viridicata*	Sister	Tello et al. (2009)
Pitangus sulphuratus	*Pitangus lictor*	Sister	Tello et al. (2009)
Tyrannopsis sulphurea	*Megarynchus pitangua*	Sister	Tello et al. (2009)
Phylloscartes nigrifrons	*Phylloscartes ventralis*	Sister	Tello et al. (2009)
Cnipodectes subbrunneus	*Taeniotriccus andrei*	Sister	Tello et al. (2009)
Hemitriccus iohannis	*Hemitriccus margaritaceiventer*	Sister	Tello et al. (2009)
Cercomacra tyrannina	*Cercomacra serva*	Sister	Tello et al. (2014)
Carpodacus purpureus	*Carpodacus cassinii*	Sister	Tietze et al. (2013)
Anthus lutescens	*Anthus spragueii*	Sister	Voelker (1999)
Dendrocincla fuliginosa	*Dendrocincla anabatina*	Sister	Weir and Price (2011)
Cardinalis phoeniceus	*Cardinalis cardinalis*	Sister	Yuri and Mindell (2002)
Toxostoma guttatum	*Toxostoma longirostre*	Most closely	Zink et al. (1999)
Toxostoma lecontei	*Toxostoma crissale*	Sister	Zink et al. (1999)
Toxostoma cinereum	*Toxostoma bendirei*	Sister	Zink et al. (1999)
Polioptila californica	*Polioptila melanura*	Sister	Zink et al. (2000)

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Empidonax alnorum	*Empidonax traillii*	Sister	Zink and Johnson (1984)
Agriornis montanus	*Agriornis micropterus*	-	Not found
Anisognathus notabilis	*Calochaetes coccineus*	-	Not found
Anthus correndera	*Anthus hellmayri*	-	Not found
Atlapetes albinucha	*Atlapetes pileatus*	-	Not found
Atlapetes schistaceus	*Atlapetes melanopsis*	-	Not found
Cercomacra cinerascens	*Cercomacra carbonaria*	-	Not found
Chamaeza mollissima	*Chamaeza campanisona*	-	Not found
Chiroxiphia pareola	*Chiroxiphia caudata*	-	Not found
Conopophaga peruviana	*Conopophaga aurita*	-	Not found
Contopus cinereus	*Contopus sordidulus*	-	Not found
Contopus cooperi	*Contopus fumigatus*	-	Not found
Cymbilaimus lineatus	*Cymbilaimus sanctaemariae*	-	Not found
Dacnis venusta	*Dacnis cayana*	-	Not found
Dendroica castanea	*Dendroica striata*	-	Not found
Dendroica pensylvanica	*Dendroica petechia*	-	Not found
Drymophila squamata	*Drymophila genei*	-	Not found
Epinecrophylla erythrura	*Epinecrophylla leucophthalma*	-	Not found

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Epinecrophylla haematonota	*Epinecrophylla spodionota*	-	Not found
Euphonia finschi	*Euphonia chlorotica*	-	Not found
Euphonia laniirostris	*Euphonia hirundinacea*	-	Not found
Formicarius nigricapillus	*Formicarius analis*	-	Not found
Furnarius cristatus	*Furnarius rufus*	-	Not found
Grallaria varia	*Grallaria guatimalensis*	-	Not found
Grallaricula nana	*Grallaricula lineifrons*	-	Not found
Henicorhina leucosticta	*Thryothorus ludovicianus*	-	Not found
Hylocichla mustelina	*Zoothera pinicola*	-	Not found
Hylophilus decurtatus	*Hylophilus ochraceiceps*	-	Not found
Hymenops perspicillatus	*Muscisaxicola fluviatilis*	-	Not found
Knipolegus cyanirostris	*Knipolegus aterrimus*	-	Not found
Lepidothrix coronata	*Lepidothrix nattereri*	-	Not found
Lessonia oreas	*Lessonia rufa*	-	Not found
Lophotriccus galeatus	*Lophotriccus vitiosus*	-	Not found
Mackenziaena leachii	*Mackenziaena severa*	-	Not found
Mecocerculus minor	*Mecocerculus calopterus*	-	Not found
Myiobius villosus	*Myiobius sulphureipygius*	-	Not found

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Myiozetetes luteiventris	*Myiozetetes similis*	-	Not found
Myrmotherula ignota	*Myrmotherula brachyura*	-	Not found
Myrmotherula longipennis	*Myrmotherula axillaris*	-	Not found
Myrmotherula menetriesii	*Myrmotherula assimilis*	-	Not found
Onychorhynchus occidentalis	*Onychorhynchus coronatus*	-	Not found
Oryzoborus crassirostris	*Oryzoborus maximiliani*	-	Not found
Petrochelidon pyrrhonota	*Petrochelidon fulva*	-	Not found
Phacellodomus striaticeps	*Phacellodomus rufifrons*	-	Not found
Phacellodomus striaticollis	*Phacellodomus ruber*	-	Not found
Philydor lichtensteini	*Megaxenops parnaguae*	-	Not found
Phyllomyias burmeisteri	*Phyllomyias uropygialis*	-	Not found
Phyllomyias sclateri	*Stigmatura budytoides*	-	Not found
Pipra pipra	*Machaeropterus deliciosus*	-	Not found
Pipreola intermedia	*Pipreola arcuata*	-	Not found
Platyrinchus mystaceus	*Platyrinchus saturatus*	-	Not found
Progne chalybea	*Progne sinaloae*	-	Not found
Pseudocolopteryx acutipennis	*Pseudocolopteryx flaviventris*	-	Not found
Ramphocaenus melanurus	*Microbates cinereiventris*	-	Not found

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Saltator grossus	*Saltator aurantiirostris*	-	Not found
Sayornis phoebe	*Sayornis nigricans*	-	Not found
Sicalis lutea	*Sicalis luteocephala*	-	Not found
Spizella breweri	*Spizella pusilla*	-	Not found
Sturnella superciliaris	*Sturnella loyca*	-	Not found
Synallaxis azarae	*Synallaxis albescens*	-	Not found
Thamnophilus insignis	*Thamnophilus amazonicus*	-	Not found
Thryothorus coraya	*Thryothorus euophrys*	-	Not found
Todirostrum pictum	*Todirostrum maculatum*	-	Not found
Tolmomyias assimilis	*Tolmomyias sulphurescens*	-	Not found
Tyrannus forficatus	*Tyrannus verticalis*	-	Not found
Tyrannus savana	*Tyrannus dominicensis*	-	Not found
Tyrannus vociferans	*Tyrannus tyrannus*	-	Not found
Vireo atricapilla	*Vireo bellii*	-	Not found
Vireo flavoviridis	*Vireo altiloquus*	-	Not found
Vireo philadelphicus	*Vireo leucophrys*	-	Not found
Vireo plumbeus	*Vireo cassinii*	-	Not found
Vireo vicinior	*Vireo huttoni*	-	Not found

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Xolmis rubetra	*Neoxolmis rufiventris*	-	Not found
Xolmis velatus	*Xolmis irupero*	-	Not found
Sitta pusilla	*Sitta pygmaea*	-	Not found
Icteria virens	*Teretistris fernandinae*	-	Not found
Myadestes townsendi	*Myadestes obscurus*	-	Not found
Polioptila nigriceps	*Polioptila albiloris*	-	Not found
Phytotoma rutila	*Phytotoma rara*	-	Not found
Cyanocorax caeruleus	*Psilorhinus morio*	-	Not found
Heliobletus contaminatus	*Philydor pyrrhodes*	-	Not found
Phacellodomus maculipectus	*Phacellodomus erythrophthalmus*	-	Not found
Phyllomyias virescens	*Phyllomyias plumbeiceps*	-	Not found
Platyrinchus leucoryphus	*Platyrinchus coronatus*	-	Not found
Pyrrhocoma ruficeps	*Hemispingus superciliaris*	-	Not found
Synallaxis spixi	*Synallaxis stictothorax*	-	Not found
Asthenes pudibunda	*Asthenes pyrrholeuca*	-	Not found
Chamaeza nobilis	*Chamaeza meruloides*	-	Not found
Melanopareia torquata	*Melanopareia maximiliani*	-	Not found
Myiotheretes fumigatus	*Xolmis coronatus*	-	Not found

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Ochthoeca pulchella	*Colorhamphus parvirostris*	-	Not found
Phylloscartes poecilotis	*Phylloscartes sylviolus*	-	Not found
Poospiza caesar	*Donacospiza albifrons*	-	Not found
Porphyrospiza caerulescens	*Phrygilus fruticeti*	-	Not found
Atlapetes rufinucha	*Atlapetes tricolor*	-	Not found
Basileuterus signatus	*Basileuterus basilicus*	-	Not found
Campylorhynchus albobrunneus	*Campylorhynchus zonatus*	-	Not found
Chiroxiphia boliviana	*Antilophia galeata*	-	Not found
Chlorophonia occipitalis	*Chlorophonia flavirostris*	-	Not found
Cinnycerthia peruana	*Henicorhina leucoptera*	-	Not found
Corythopis delalandi	*Corythopis torquatus*	-	Not found
Cranioleuca erythrops	*Cranioleuca subcristata*	-	Not found
Dendrocolaptes certhia	*Dendrocolaptes sanctithomae*	-	Not found
Drymophila ochropyga	*Hypocnemis cantator*	-	Not found
Dysithamnus puncticeps	*Sakesphorus cristatus*	-	Not found
Euphonia cyanocephala	*Euphonia musica*	-	Not found
Euphonia fulvicrissa	*Euphonia gouldi*	-	Not found
Herpsilochmus axillaris	*Herpsilochmus longirostris*	-	Not found

Table D.1: (continued)

Species A	**Species B**	**Relatedness**	**Published study**
Herpsilochmus parkeri	*Herpsilochmus motacilloides*	-	Not found
Herpsilochmus stictocephalus	*Herpsilochmus dorsimaculatus*	-	Not found
Hylopezus berlepschi	*Hylopezus fulviventris*	-	Not found
Hypocnemis hypoxantha	*Drymophila ferruginea*	-	Not found
Lepidothrix coeruleocapilla	*Lepidothrix iris*	-	Not found
Mitrephanes olivaceus	*Mitrephanes phaeocercus*	-	Not found
Myrmotherula cherriei	*Myrmochanes hemileucus*	-	Not found
Myrmotherula klagesi	*Myrmotherula longicauda*	-	Not found
Myrmotherula pacifica	*Myrmotherula surinamensis*	-	Not found
Myrmotherula sclateri	*Myrmotherula ambigua*	-	Not found
Ornithion inerme	*Camptostoma imberbe*	-	Not found
Phaeothlypis rivularis	*Phaeothlypis fulvicauda*	-	Not found
Phylloscartes superciliaris	*Phylloscartes ophthalmicus*	-	Not found
Pipreola pulchra	*Pipreola whitelyi*	-	Not found
Pseudocolaptes boissonneautii	*Pseudocolaptes lawrencii*	-	Not found
Ptilogonys caudatus	*Ptilogonys cinereus*	-	Not found
Rhodinocichla rosea	*Lamprospiza melanoleuca*	-	Not found
Roraimia adusta	*Thripophaga fusciceps*	-	Not found

Table D.1: (continued)

Species A	Species B	Relatedness	Published study
Sclerurus scansor	*Sclerurus guatemalensis*	-	Not found
Scytalopus atratus	*Scytalopus unicolor*	-	Not found
Scytalopus latebricola	*Scytalopus spillmanni*	-	Not found
Scytalopus micropterus	*Scytalopus femoralis*	-	Not found
Sporophila americana	*Sporophila corvina*	-	Not found
Synallaxis candei	*Synallaxis erythrothorax*	-	Not found
Synallaxis cinnamomea	*Synallaxis rutilans*	-	Not found
Tachyphonus surinamus	*Tachyphonus delatrii*	-	Not found
Thamnophilus pelzelni	*Thamnophilus sticturus*	-	Not found
Thripadectes rufobrunneus	*Thripadectes flammulatus*	-	Not found
Thryorchilus browni	*Troglodytes rufociliatus*	-	Not found
Xolmis cinereus	*Agriornis albicauda*	-	Not found
Carduelis crassirostris	*Carduelis uropygialis*	-	Not found
Carduelis lawrencei	*Carduelis psaltria*	-	Not found
Carduelis barbata	*Carduelis siemiradzkii*	-	Not found
Automolus leucophthalmus	*Automolus infuscatus*	-	Not found
Diglossa gloriosa	*Diglossa brunneiventris*	-	Not found
Diglossa humeralis	*Diglossa carbonaria*	-	Not found

Table D.1: (continued)

Species A	Species B	Relatedness	Published study
Arremon castaneiceps	*Arremon schlegeli*	-	Not found