AMERICAN MUSEUM OF NATURAL HISTORY
Richard Gilder Graduate School

Procedures and Guidelines for Preparation and Filing of the Doctoral Dissertation

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CONTENTS

Sample Pages Dissertation Guidelines

Sample Pages and Examples

Introduction

This document is intended to assist Ph.D. candidates in the Comparative Biology Program with preparation of the doctoral dissertation.

The Richard Gilder Graduate School (RGGS) requires the submission of an electronic copy of the approved dissertation with the RGGS Administrative Office prior to graduation. **The doctoral degree cannot be conferred until a dissertation in satisfactory form is completed, approved, and successfully deposited with the RGGS Administrative Office.**

The RGGS Director of Administration or other RGGS staff will conduct an annual workshop, and/or will be available to meet individually with candidates, to review dissertation preparation and filing guidelines.

Any questions relating to the physical format of the dissertation and submission requirements should be directed to the RGGS Director of Administration.

Style and Formatting

The doctoral dissertation must conform to *The Chicago Manual of Style,* 16th edition (The University of Chicago Press, 2010), which can be purchased or accessed online via Columbia University's Library at: http://www.columbia.edu/cgi-bin/cul/resolve?clio6042885 (please note that you will need to login with a valid and active Columbia University student ID and password). Should there be any disagreement between the style manual and the guidelines contained in this document, the guidelines contained herein supersede the style manual. Note that reference formatting in the style of AMNH publications also is permitted; see p. 15 for details. Questions may be directed to the RGGS Director of Administration.

Language of the Dissertation

The language of the dissertation must be English. Should the student wish to include a published paper in another language, approval must be obtained from both the student's dissertation committee and the Comparative Biology Ph.D. Program Committee (CBPPC). If approved by both, an abstract or extended summary of the paper in English must be included, as determined by the dissertation committee.

Length

There is no specific minimum or maximum page length requirement for the dissertation. It is suggested that for a dissertation primarily comprised of published papers, the introductory (first) chapter, and the concluding or summary (last) chapter, each should be approximately 10 pages in length. For a dissertation written exclusively in a narrative format, the suggested page length would be a minimum of approximately 100 pages.

Margins

The dissertation must have these minimum margins, measured by a ruler, as follows:

- Left margin: one and one-half inches (1.50")
- Top margin: one inch (1.0")
- Right margin: one inch (1.0")
- Bottom margin: one and one-quarter inches (1.25")
- Page number margin: centered, and 0.75" above the bottom edge of the page

These margins represent the distance between the edge of the paper and the text. Ruler measurement is emphasized, as a computer's margin settings may actually produce more or less than the minimum margin requirement for each side of the page. This requirement applies to all pages of the dissertation, including pages containing charts, graphs, tables, photographs, etc. Footnotes and page numbers must be contained completely inside the text area and must not extend inside the required 1¼ inch bottom margin.

If a published journal article is included in the dissertation in the actual format in which it appears in the publishing journal, it must be resized to fit the these margin requirements.

Pagination

With the exception of the title page (which is unnumbered), every page of the dissertation must be numbered; this includes tables, graphs, illustrations, and references (bibliography). All front matter (copyright page, abstract, table of contents, etc.) are numbered with lower case Roman numerals, starting with "ii" on the first page following the title page (typically, the copyright page). For the remainder of the dissertation (including appendices), starting with the Preface (if one is included) or the first page of Chapter I or its equivalent, Western Arabic numerals are used, starting with "1".

All page numbers must be placed at the center bottom of each page at least three-quarters of an inch (0.75") above the bottom edge of the page. As the margin between the bottom edge of the page and the end of the text must be a minimum of one and one-quarter inches (1.25"), this should result in the equivalent of a double space below the last line of text (or footnote) and the printed page number.

For pages containing charts or illustrations in a "landscape" format, the page number must still appear at the center bottom of the page, in the same position as the rest of the document (consistent with "portrait" format).

Pages must be numbered consecutively from beginning to end. Suffixes to page numbers, such as "17a", are not permitted.

Use only one side of each page; no facing pages are permitted, either in the text, charts, photographs, illustrations, or other non-text contents.

All pages must contain text or images. Blank pages are not permitted.

Check pagination carefully, and make sure that all pages are accounted for.

If a published journal article is included in the dissertation in the actual format in which it appears in the publishing journal, each page in the dissertation must still be consecutively numbered, consistent with these Manual instructions. As a result, some pages in the dissertation may contain the page number as it appears in the published journal article, *in addition to* the consecutive page number required for the dissertation. Keep in mind that no facing pages are permitted (only one side of each page may be used); therefore, published articles must be scanned and then assembled and presented in the format as specified in this Manual.

Type Font

The type font used must produce clear, easily readable copy, and must be a TrueType font (NOT a scalable font). Times New Roman 12 point size is recommended for the text, and 10 point size for footnotes. The font size for both text and footnotes should be no smaller than this; if a font style other than Times New Roman is used, the font size must be comparable to that specified for Times New Roman. NB: Arial has proven to be a problematic font for document transmittal; its use is strongly discouraged.

Some recommended TrueType fonts and required minimum point sizes are:

Font	Text Point Size	Footnote Point Size	Text/Number Point Size within Figures and Tables
Century	11pt	9pt	4-6pt
*Courier New	10pt	8pt	4-6pt
Garamond	12pt	10pt	4-6pt
*Georgia	11pt	8pt	4-6pt
Lucida Bright	10pt	8pt	4-6pt
Microsoft Sans Serif	10pt	8pt	4-6pt
Tahoma	10pt	8pt	4-6pt
*Times New Roman	12pt	10pt	4-6pt
*Trebuchet MS	10pt	8pt	4-6pt
*Verdana	10pt	8pt	4-6pt

*Web font. Designed for easy screen readability. Since many readers are likely to view and/or use your dissertation onscreen, you may wish to improve the readability of your text by using one of these fonts. (*Source: ProQuest Dissertation Publishing*)

The same style of font or typeface that appears in the main body of the text must also be used in all headers, page numbers, and footnotes. Exceptions are made only for tables and figures produced by different technology or by graphic artists, or reproductions of published papers included within the dissertation. If there is any doubt about the type font,

a sample should be presented to the RGGS Director of Administration for review and approval prior to preparation of the dissertation.

All text must be printed clearly in black ink. Color may be included in the dissertation for charts, graphs, photographs, and other illustrative materials, as it will reproduce well in both PDF and print formats. Bear in mind that if the dissertation is ever preserved on microfilm/microform, colors other than black will not reproduce, and will appear only in shades of gray.

Accent marks, diacritical marks, and symbols should be printed whenever possible. Hand writing of accent marks, diacritical marks, and symbols is strongly discouraged.

Spacing

The text of the dissertation must be double-spaced. Do not quadruple space between headings and text or in between paragraphs; indentation denotes paragraphs. Long quotations, footnotes/endnotes, and bibliography or reference list are set up with single-spacing or double-spacing as specified in *The Chicago Manual of Style*. If title or chapter headings exceed one line in length, they should be single-spaced. If using lists in your text, single-space the entries and double-space between each entry. Full justification of the right margin of the text is not permitted. You may hyphenate words to get rid of "widows" and "orphans".

If reproductions of published papers are included within the dissertation, the above spacing requirements do not apply.

Footnotes/Endnotes

Textual notes that provide bibliographic references, supplementary information, opinions, explanations, or suggestions that are not part of the text itself must appear either at the end of each chapter as an endnote, or alternatively at the bottom of the page as a footnote. If footnotes are used, the footnote must be included on the same page as the referenced passage; lengthy footnotes may be continued on the next page, but must begin on the same page as the referenced passage. If the student will be including reproductions of published papers as chapters within the dissertation, endnotes are strongly encouraged in lieu of footnotes. Regardless of which method is adopted, the notations must be consistent throughout the entire dissertation (either as endnotes at the end of each chapter, or as footnotes).

Footnote/endnote numbering can be continuous throughout the dissertation, or may start again for each chapter, but the method must be consistent. Footnotes/endnotes may be single-spaced within each entry, but must be double-spaced between each entry. A smaller point size may be used for footnotes/endnotes than the point size used for the text, though the same font must be used.

If published papers that include footnotes/endnotes will be used in the dissertation, it is suggested that footnote/endnote numbering start again with each chapter. However, if the student will be including additional footnotes/endnotes within a given chapter that contains a published paper with footnotes/endnotes, the student should disregard the footnote/endnote numbering within the published paper, and maintain a consistent numbering system throughout the dissertation for any additional footnotes/endnotes that are included – either by use of continuous numbering throughout the entire dissertation, or restarted numbering for each chapter.

For references accessed electronically, the URL must be included within the footnote/endnote reference. The inclusion of dates upon which the student accessed the source is optional, and is only recommended for sources likely to have substantive updates. See *The Chicago Manual of Style* for further information on citation of electronic resources.

Figures, Tables, and Illustrations

Prior to submission, all photos, charts, or other non-text content must be scanned for inclusion in the digital (PDF) copy; GIF (.gif), JPEG (.jpg), and TIFF (.tiff) are generally accepted for images. Other formats should be approved in advance by the Director of Administration.

Tables and illustrations – including photographs – are used to enhance the dissertation and must be referenced in the text. The size of the illustrative material will determine where it is placed within the dissertation. If it is small, it can be placed on the page with the text above/below as reference. Larger illustrations or tables can be placed on the page following the first point of reference. Large items must be reduced to fit the page size. Using landscape orientation is also an option[1]. Alternatively, images/figures may be placed at the end of the chapter in which they are referenced.

Figure and table numbering must be either continuous throughout the dissertation or by chapter (e.g., 1.1, 1.2, 2.1, 2.2, etc.). For example, there cannot be two figures designated in the dissertation as "Figure 7." Figures and Tables should each be numbered independently of each other; that is, you may have Table 1.1, 1.2 etc as well as Figure 1.1, 1.2.

Headings of tables should be placed at the top of the table in size 10 or 12 font. A consistent format must be used throughout the dissertation, except for tables in published articles that are included within the dissertation, and would therefore follow the format of the publisher.

[1] See "*Tips for preparing landscape charts, images, tables & pages for the Electronic Submission of a Dissertation Including page number & portrait mode requirements*" https://library.albany.edu/libdru/imc/pdf/dissertation_landscape.pdf

Captions of figures should be placed at the bottom of the figure in size 10 or 12 font. If the figure takes up the entire page, the figure caption should be placed alone on the preceding page and centered vertically and horizontally within the margins. Each page receives a separate page number. When a figure or table title is on a preceding page, the second and subsequent pages of the figure or table should say, for example, "Figure 7 (Continued)." In such instances, the list of figures or tables (if used) will list the page number containing the title. The word "Figure" should be written in full (not abbreviated) when the word is used in running text, but you may use the full word or the abbreviation "fig." within the parentheses in the caption, capitalized (e.g. "Fig. 1.3" or "Figure 1.3")

Horizontal figures and tables (i.e., those landscaped on the page) must be positioned correctly and bound at their top, so that the top of the figure or table will be at the left margin of the dissertation as a whole. Figure and table headings/captions are placed with the same orientation as the figure or table when on the same page. When on a separate page, headings/captions are always placed in horizontal orientation, regardless of the orientation of the figure or table. Page numbers are always placed as if the figure were vertical on the page (consistent with "portrait" format).

The minimum required margins must be maintained on pages with figures, tables or illustrations.

If a graphic artist does the figure, RGGS will accept lettering done by the artist only within the figure. Figures done with software are acceptable if the figures are clear and legible. Legends and titles done by the same process as the figures will be accepted if they too are clear, legible, and run at least 10 or 12 characters per inch (e.g. 10 or 12 point font). Otherwise, legends and captions should be printed with the same font used in the text.

If illustrations, figures, or tables are included within a published article that will be used within the dissertation, the existing figure heading and numbering can remain intact. If an illustration, figure or table is being excerpted and included within narrative text that is not part of a published article, then the above guidelines pertaining to heading and numbering should be followed.

Maintain the same view (portrait or landscape) for each entire table. Also, images used must have an effective resolution of at least 300 ppi for good printing quality in the bound archival copy. All copyright laws must be observed for illustrative materials, as well as text.

Oversized Materials and Supplementary Digital Material

For the print copies of the dissertation, foldouts are discouraged. However, if reduction would make a figure too small to be easily legible or understood, it can be duplicated by photography, photo offset, or printed on 11" x 17" (or larger) archival paper and then folded so that it fits inside the edges of the dissertation and can be unfolded flat for perusal. The oversized sheet should be folded to allow one and one-half inch (1.50") on the binding edge and a smaller page overall – about 8" x 10 ½" – so that the bindery can trim the edges

of the dissertation without slicing into the folds (the folded page should not fully extend to the top, right, or bottom edges of the standard 8 ½" x 11" page size, as ALL page sides will be trimmed as much as and eighth of an inch – or more – from each of the open edges as part of the binding process).

Likewise, many dissertations may include digital materials, such as audio or visual files. Media files should NOT be embedded in the final electronic version of the dissertation; they should be uploaded separately from the digital (PDF) copy of the dissertation. Acceptable video formats include: Apple Quick Time (.mov), Microsoft Audio Video Interleaved (.avi), and MPEG (.mpg). Acceptable audio formats include: AIF (.aif), MIDI (.midi), SND (.snd), and WAV (.wav); other formats must be reviewed and approved in advance by the Director of Administration. For the print copies of the dissertation, digital materials may be included on a CD or DVD, or other storage media approved in advance by the Director of Administration, which can be inserted in a specially prepared pocket at the back of the dissertation.

Authorship: author attribution statements are needed where others collaborated on the research presented in any chapter. This can be put in the Introductory chapter, the abstract of the individual chapter, or as a footnote on the first page of the chapter. Use of the collective "we" in a chapter denotes more than one author. Therefore an author attribution must be made OR the student must rewrite the chapter using the singular "I".

Copyright

The Richard Gilder Graduate School (RGGS) and the American Museum of Natural History (AMNH) assume no liability for copyright violations.

Standard citation of others' copyrighted works that are in accordance with "fair use" does not require permission from the copyright holder prior to use in dissertations. The republication of tables, charts, images, etc. from previously published works, authored by others or the student, does require permission from the copyright holder. Although most publishers automatically grant student authors the right to republish their own accepted or published work(s) as part of dissertations, confirmation of that right should be obtained prior to inclusion. All permissions must be obtained in writing, and included in an appendix. If permission is granted electronically – such as by email communication – the email must be included in the appendix, in accordance with formatting requirements noted herewith (for margins, pagination, etc.). A sample permission letter to request use of previously copyrighted material is provided at the end of these guidelines for reference. Many journals and publishing companies have online forms to be used for permission requests.

If copyrighted material belonging to others is used in the dissertation, the student must give full credit to the author and publisher of the work used. If a quotation exceeds "fair use," permission from the copyright owner must be obtained. According to the Association

of American University Presses[2], permission is required for quotations that are reproduced as complete units – letters, essays, journal articles, complete chapters or sections of books, maps, charts, graphs, tables, figures, drawings, or other illustrative materials. To determine whether other excerpts from copyrighted material exceed "fair use" criteria, consider the length and substantiality of the portion quoted, the nature of the copyrighted work quoted, how the use of the excerpt will affect the market for or value of the quoted work, and the purpose and character of its use, including whether it is commercial in nature or for nonprofit educational use. When in doubt, the safest course is to obtain permission.

If material in a dissertation is co-authored, permission from the author(s) to use this material is required, unless the publisher alone has the right to grant copyright permission. In most cases, there will be co-authors of previously published or recently submitted journal articles. If copyright has not been signed away to the journal publisher, then the co-authors should grant permission. If copyright has been signed away by the authors to the publisher, then the student need only obtain permission from the publisher to include the copyrighted material in the dissertation.

Permission to use copyrighted material is obtained from the owner of the copyright. If a student includes in the dissertation his or her own previously published material, and if the student had granted publication rights to the publisher (most publishers require that this right be granted), then the student must obtain permission from the publisher to include this material in the dissertation. When images or quotations from materials obtained from libraries, archives, museums, and the like are included in the dissertation, students should also follow the policies of the respective repositories concerning permission requirements.

Copies of permission to reprint letters, articles, etc. must follow the Appendices, immediately preceding the CV, if one is included.

Using Published Materials

You may use your published article(s) in the publication's format, as either a part of or as an entire dissertation Chapter. The article must have been published or been accepted for publication (and now considered "in press.") If the article has been accepted, but with "minor revisions," please see the Director of Administration for how to proceed.

For published articles:
If a published journal article is to be included in the dissertation in the actual format in which it appears in the publishing journal, each page in the dissertation must still be consecutively numbered, consistent with the instructions in this Manual. As a result, some pages in the dissertation may contain the page number as it appears in the published journal article, in addition to the consecutive page number required for the dissertation. The student should also keep in mind that no facing pages are permitted (only one side of

[2] The Association of American University Presses (AAUP) maintains extensive resources for copyright and permissions questions, as well as information guides to current copyright litigation and legislation, and has a useful FAQ on copyright matters: http://www.aaupnet.org/aboutup/issues/copyright/index.html

each page may be used); therefore, published articles must be scanned or downloaded in an appropriate format and then assembled and presented as specified in this Manual.

For articles in press:
For articles in press (but not yet in proof), submitted for publication, or in preparation for submission, the article must be appropriately formatted within the dissertation consistent with formatting requirements specified in this Manual. Such chapters should begin with an abstract of the article. It is typically unnecessary to include the addresses of authors, grant numbers, journal addresses, etc. that are part of the source manuscript within the dissertation. All figures and tables in such chapters must be numbered consecutively within the overall context of the dissertation. Also, if the source manuscript of a chapter has individual acknowledgements, these must be deleted from the chapter and added to the general dissertation Acknowledgements at the front of the dissertation.

If the published article is being used as the entire Chapter, it is recommended that you include an introductory statement to provide context; the article's abstract will serve as the Chapter abstract. References can appear as they do in the publication's format and do not need to be changed.

Order and Content

The following parts typically comprise a doctoral dissertation. The order of the listing should be observed regardless of parts that may be omitted or combined in a particular dissertation.

NOTE: Items that are considered OPTIONAL are indicated with an asterisk (*).
Items without an asterisk are typically considered to be REQUIRED components of the dissertation.

Traditional "Narrative" Format

Preliminary Materials

Title Page
Copyright Notice*

A copyright notice is only required if the dissertation author intends to file for copyright.

Abstract
Dedication*
Acknowledgements*
Epigraph*
Table of Contents
Figures, Tables, and Illustrations*
Abbreviations*
Glossary*

Journal Article or "Mixed" Format

Preliminary Materials

Title Page
Copyright Notice*

A copyright notice is only required if the dissertation author intends to file for copyright.

Abstract
Dedication*
Acknowledgements*
Epigraph*
Table of Contents
Figures, Tables, and Illustrations*
Abbreviations*
Glossary*

Main Body	**Main Body**
Preface*	Preface*
Chapter 1 – Introduction	Chapter 1 – Introduction
The first chapter typically serves as the detailed introduction to the dissertation; however, dissertation authors have the option of including a section labeled as "Preface," which appears prior to the first chapter, and provides a more general introduction to the dissertation, such as motivations for the study, background information, the purpose of the paper, etc. (in such instances, the first chapter should still serve as the more detailed introduction to the dissertation).	
Chapter 2 – Literature Review	Chapter 2 – Topic/Manuscript #1
Chapter 3 – Methods	Chapter 3 – Topic/Manuscript #2
Chapter 4 – Results	Chapter 4 – Topic/Manuscript #3
*The total number of chapters **may vary**.*	
Chapter V – Conclusions/Limitations and Discussion, Future Work*	Chapter V – Conclusions/ Limitations and Discussion, Future Work*

End Matter	**End Matter**
Bibliography/References Cited	References Cited* *Alternatively, references may be provided at the end of each chapter.*
Appendices	Appendices
- Measurement Instruments*	- Collections Accessed/ Specimens Studied
	- Extended Literature Review*
- Additional Materials*	- Extended Theoretical Development/Framework*
- Samples*	- Additional Methodology*
	- Additional Results*
	- Additional Materials*
- Permission Letters*	- Permission Letters
Permission letters must be included for any reprinted items, Including published articles, manuscripts, illustrative materials, etc.	
Curriculum Vitae*	Curriculum Vitae*

NOTE: Sample pages for most of the following parts of the dissertation are provided at the end of this document.

Title Page ***(Required)***

The dissertation begins with a title page. The title should be as concise as possible, consistent with giving an accurate description of the dissertation. Be sure to use words for formulas, symbols, Greek letters, and so on, on the title page.

The date on the title page should be the month and year that the Dissertation Defense Approval form was signed.

Copyright Notice *(Optional)*

The Copyright Act of 1976 provides for statutory copyright protection of a work from the moment it is tangibly fixed. To secure this protection, a copyright notice should be affixed on a separate page immediately following the title page. If a student requests copyright registration, RGGS will send copies of the dissertation to the Copyright Office in Washington, DC. The Copyright Office will then send registered copies to the Library of Congress. Under mandatory deposit requirements, RGGS also sends copies of all dissertations to the Library of Congress upon their request. A fee applies to the service of archiving and disseminating copyrighted dissertations. If the student desires, they may cover any fees from their remaining RGGS research budget. The student will receive a copyright certificate from the Copyright Office.

Copyright is automatically vested with authors, as dissertations are written and saved in a fixed format. Inclusion of the copyright notice is necessary if the student wishes to file for official copyright registration.

Abstract *(Required)*

The abstract should summarize the dissertation, including a statement of the research problem(s), methods and procedures used, and the main results or conclusions of the research. Although there is no defined word limit, it is suggested that the abstract be as concise as possible and kept to no more than 350 words, which is standard for most doctoral dissertations published in the United States. Please note that this abstract is separate from any abstract that may precede an individual chapter, published or written for publication.

Dedication *(Optional)*

The inclusion of a dedication is optional. If a dedication is included, it is recommended that it be brief, and not extravagant or humorous.

- Should be begin about 1/3 down the page
- Words of the dedication should be italicized
- Dedication should not have terminal punctuation

Acknowledgements *(Optional)*

Acknowledgements are optional, but the majority of dissertation authors do include this section. It provides an opportunity to recognize and express appreciation to those who encouraged and assisted the student in their graduate education and research, such as mentors, colleagues, individuals, funding agencies, etc., who may have provided assistance and support.

Epigraph ***(Optional)***

An epigraph, which is optional, consists of a pertinent quotation at the beginning of the dissertation, establishing a general theme for the paper. Epigraphs can also be included at the beginning of a chapter, to capture the unique theme of an individual chapter.

- Epigraph page should not have a heading
- Epigraph should not be enclosed in quotation marks
- Epigraph should be italicized
- Should be begin about 1/3 down the page

Table of Contents ***(Required)***

A table of contents is required, providing an outline of the major chapters and/or sections with corresponding page numbers. Sub-headings can be broken down under the chapter or section, but this is not required. All headings should be worded identically to those used in the text.

- Be sure to match the formatting of the sample pages provided

Figures, Tables, and Illustrations ***(Optional)***

The inclusion of a list of figures, tables, and illustrations is optional. However, if the dissertation contains a relatively substantial number of any of these, a list is recommended to aid the reader. If there are relatively few, they may be combined into one list (e.g., "Figures and Tables," or "Tables and Illustrations," or "Figures, Tables, and Illustrations," etc.). If there are a significant number, it is suggested that they included as separate lists (e.g., "Figures" on one page, "Tables" on a separate page, and "Illustrations" on a separate page).

There are three acceptable locations for tables and figures:

- within the chapter immediately following first reference to them
- grouped at the end of the relevant chapter
- grouped at the end of the thesis before the bibliography

You must use the same option consistently throughout the dissertation.

Accession Numbers ***(Required)***

Accession numbers for any AMNH holdings and/or collections held elsewhere that are referenced in your work must be cited. You must also included an accession number for any data uploaded to GitHub. When referencing just a single item, include the accession number within the narrative at that point. Numerous accession numbers may appear as a list or table in a numbered Appendix to which you should refer the reader in the main body text. The copy of your dissertation that you submit to your Committee for their determination of whether or not it is ready to defend can be submitted without the accession numbers; the final version that you deposit must have the accession numbers included. Students unable to obtain accession numbers should consult the Director of

Administration for how to proceed.

Abbreviations ***(Optional)***
A list of abbreviations is optional, and should only be included if the dissertation includes an unusual number of uncommon abbreviations. The inclusion of an abbreviations section is common for dissertations that include collection acronyms, anatomical abbreviations, etc. Examples of uncommon abbreviations might include organizations that are not widely known, or sources that are frequently cited and abbreviated throughout the dissertation. For example, "NATO" would be considered a common abbreviation, while "RGGS" would be considered an uncommon abbreviation. An alternative to including an abbreviation list in the front matter of the dissertation is to include an abbreviation list at the beginning of each chapter, addressing abbreviations used within that specific chapter.

Glossary ***(Optional)***
A glossary is optional, and should only be included if the dissertation contains a significant number of foreign or technical words and phrases that are not commonly familiar to most readers.

Preface ***(Optional)***
The first chapter typically serves as the detailed introduction to the dissertation; however, dissertation authors have the option of including a section labeled as "Preface," which appears prior to the first chapter, and provides a more general introduction to the dissertation, such as motivations for the study, background information, the purpose of the dissertation, etc. (in such instances, the first chapter should still serve as the more detailed introduction to the dissertation).

Chapters ***(Required)***
Each chapter should begin on a new page and should exactly reflect the title as listed in the Table of Contents.

> The **first chapter** should serve as a detailed introduction, and should prepare the reader for what follows by stating the specific problem(s) or question(s) studied and the research strategy(ies) used. It may delineate the boundaries of the problem(s) or question(s), and it may review studies pertinent to the dissertation. If the dissertation includes published articles (or manuscripts to be submitted for publication) as chapters, the student should provide a statement of its relationship to their research. In the case of multiple authorship, the student should provide a statement explicating her or his particular input and effort into each piece of work, and its relationship to the student's research. The student should also state that any stylistic variations result from the demands of the journal or publisher to which the paper was submitted, accepted, or published.
>
> It is also important to clearly state the status of each manuscript submitted, accepted or published. This can be done in the Table of Contents, the

first/introductory chapter, or at the beginning of the chapter containing the manuscript – by including a statement that the manuscript has been submitted, accepted or published, including the journal name for accepted and published papers.

The **intermediate chapters** in a traditional "narrative" dissertation are typically organized to discuss Literature Review, Methods, and Results. In a dissertation consisting primarily of journal articles or a mixture of narrative chapters and journal articles (published or in manuscript), individual chapters may be devoted to specific topics or manuscripts.

If a published article or proof version of an article in press is to be included in the dissertation in the actual format in which it appears in the publishing journal or other publication, it must be resized to fit the margin requirements as specified in this Manual.

For articles in press (but not yet in proof), submitted for publication, or in preparation for submission, the article must be appropriately formatted within the dissertation consistent with formatting requirements specified herewith. Such chapters should begin with an abstract of the article. It is typically unnecessary to include the addresses of authors, grant numbers, journal addresses, etc. which are part of the source manuscript within the dissertation. All figures and tables in such chapters must be numbered consecutively within the overall context of the dissertation. Also, if the source manuscript of a chapter had individual acknowledgements, these must be deleted from the chapter and added to the general dissertation Acknowledgements at the front of the dissertation.

The **final chapter** of the dissertation must provide a discussion of the student's research results, findings, and conclusions.

References (or Bibliography) *(Required)*

References are typically provided at the end of each chapter of the dissertation, and this is the preferred method[3].

The References section should begin on a new page and include every book, article, thesis or dissertation, abstract, videotape, website, etc. mentioned in the dissertation with complete publishing information. Other sources, such as interviews, are also listed with appropriate information about when and where they took place.

[3] Students do have the option of including a comprehensive References (or Bibliography) section at the end of the entire dissertation. This should be treated as a section similar to appendices and included in the Table of Contents

Reference formatting should follow the style of the RGGS sample pages below OR the style of AMNH publications is permitted:

Author info: http://www.amnh.org/our-research/scientific-publications/for-authors/style-manual
Style manual: http://www.amnh.org/content/download/73849/1383513/file/style-manual-2014.pdf
Endnote plug-in for AMNH reference style: http://research.amnh.org/scipubs/f/endnote-instructions6-7.ens
Endnote instructions for AMNH reference style: http://research.amnh.org/scipubs/f/endnote-instructions5-13.pdf

Appendices ***(Typically Required)***
Appendices may include any supplementary materials that support or are relevant to the dissertation but that have no logical or appropriate place within the body of the text. Permission letters must be included in an appendix for any reprinted items, including published articles, manuscripts, illustrative materials, etc.

Curriculum Vitae ***(Optional)***
The inclusion of the student's curriculum vitae at the end of the dissertation is optional.

Submission

Submission of an electronic (PDF) of the dissertation is required by RGGS two weeks before the dissertation defense. The rest of this information applies to submission of the dissertation post-defense.

The full text of the electronic dissertation will be publicly available, either immediately or after an embargo period, during which time access will be restricted to AMNH IP only. An embargo may also apply only to specific portions of the dissertation. The length of any embargo period will be determined by the RGGS on an individual basis, taking into consideration the student's request explicating the sensitivity of unpublished research contained within the dissertation. Students must complete an embargo request form, if applicable, for review and potential approval by the RGGS.

Submission of the dissertation is not made until all changes from the final oral defense, if required, have been incorporated, and the student has obtained all relevant dissertation committee approvals, at which point the dissertation is considered complete and ready for review and approval by the RGGS. You must submit both a pdf and Word version. It will be reviewed for formatting by the Director of Administration or his/her delegate and if revisions are needed you will be contacted and asked to make revisions then. You will submit the revised version again (in Word and pdf) for the Dean's final review and approval.

Through an electronic release agreement, students grant a license to the AMNH to make the work publicly accessible in the current and potential future formats, which enables the AMNH Library or other RGGS-assigned archive to maintain and preserve the electronic copy of the dissertation.

All fonts must be embedded before submitting the final electronic (PDF) version of the dissertation. Embedding the fonts means that you are saving the actual font files within your document. Through this process you can be assured that everyone who opens the document will see it the way you intended, even if they do not have the fonts you used installed. To embed fonts:

Mac OS, Word for Mac

1. In Word for Mac, under 'File', choose 'Print'
2. Click on the 'PDF' button in the lower left, and choose 'Save as PDF'
3. Make sure the file name ends in '.pdf' and click 'Save'

Windows OS, Word 2003

1. In Word, under Adobe PDF, choose 'Change Conversion Settings'
2. Click on the 'Advanced Setting' button
3. Choose the 'Fonts' folder at the upper left
4. Check the checkbox labeled 'Embed all fonts'
5. Make sure the textbox under 'Never Embed" is completely empty
6. Save these settings
7. Click on 'Convert to Adobe PDF' located under 'Adobe PDF'
8. Once you have created your PDF file, open it with Adobe Acrobat, and look at 'Properties' under 'File'
9. Using the 'Fonts' tab in Acrobat, you should see that all of your fonts have been embedded (e.g. Embedded Subset)
10. Check the security tab to make sure it says 'No Security'

Windows OS, Word 2007 and later Versions (as of Nov. 2014)

1. In Word, select the 'Acrobat' tab
2. Click on the 'Preferences' button near the upper left, then select 'Advanced Settings' in the pop up window
3. Follow steps 3-10 as noted above for Word 2003

Examples and Sample Pages

Directions for References: Include your references at the end of each Chapter, starting on a new page. Single spacing as shown is preferred, with a line space between each reference. List publications alphabetically by author. Multiple publications by the same author or by the same two authors should be ordered chronologically in the following format (unless following the format of the AMNH Style Guide).

References

Andrews, Timothy J., Scott D. Halpern, and Dale Purves. 1997. "Correlated size variations in human visual cortex, lateral geniculate nucleus, and optic tract." *The Journal of Neuroscience* 17(8): 2859-2868.

Balanoff, Amy. 2011. *Oviraptorosauria: Morphology, Phylogeny, and Endocranial Evolution*. Ph. D. Dissertation. Columbia University.

Balanoff, Amy M., Gabe S. Bever, Timothy B. Rowe, Mark A. Norell. 2014. "Evolutionary origins of the avian brain." *Nature* 501(7465): 93-96.

Bruehlmeier, Matthias, Barbara Kaser-Hotz, Roger Achermann, Carla Rohrer Bley, Melanie Wergin, Pius A. Schubiger, and Simon M. Ametamey. 2005. "Measurement of tumor hypoxia in spontaneous canine sarcomas." *Veterinary Radiology and Ultrasound* 46(4):348-354.

Casteels, Cindy, Peter Vermaelen, Johan Nuyts, Annemie Van Der Linden, Veerle Baekelandt, Luc Mortelmans, Guy Bormans, and Koen Van Laere. 2006. "Construction and evaluation of multitracer small-animal PET probabilistic atlases for voxel-based functional mapping of the rat brain." *Journal of Nuclear Medicine* 47:1858-1866.

Chai, C.Y., Wang, S.C. 1962. "Localization of central cardiovascular control mechanism in lower brain stem of the cat." *American Journal of Physiology* 202(1): 25-30.

Chen, Pei-ji, Zhi-ming Dong, and Shuo-nan Zhen. 1998. "An exceptionally well-preserved theropod dinosaur from the Yixian Formation of China." *Nature* 391(6663): 147–152.

Cossar Ewart, J. 1921. The nestling feathers of the mallard, with observations on the composition, origin, and history of feathers. *Proceedings of the Zoological Society of London:* 609–642.

Directions for Table of Contents: Use small caps throughout. All titles must match those in the text. Use of the MS Word Table of Contents function is recommended so that page changes during revisions are automatically reflected and updated. Please format according to the example below, including punctuation.

Directions for text headings: "Chapter (and Roman Numeral)" is small caps and bold, as is the title of the Chapter. Major headings such as Abstract, Introduction, Materials and Methods, Results and Discussion are in regular font, bold, and centered. A further subheading within these sections, such "Taxa and Characters" and "Phylogenetic analyses", should appear left justified and italicized. Any additional deeper-level headings will also be left-justified and italic.

CHAPTER I

DIRECT OPTIMIZATION, SENSITIVITY ANALYSIS, AND THE EVOLUTION OF THE HYMENOPTERAN SUPERFAMILIES

Abstract

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Introduction

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Materials and Methods

Taxa and characters

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Phylogenetic analyses

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Results and Discussion

Your text starts here, with a paragraph indent. Then continues, continues, continues.

MOTHER-INFANT RELATIONSHIPS AS THE BEDROCK OF ALL MAMMALIAN SOCIAL BEHAVIOR

Titles: Bold; Small caps; capitalize the first letter of each word, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

maintain narrower margins for the sections below per example

A Dissertation
submitted to the Faculty of
The Richard Gilder Graduate School
at the
American Museum of Natural History
in partial fulfillment of the requirements for
the degree of
Doctor of Philosophy

By

John A. Doe, M.S.

Richard Gilder Graduate School
at the
American Museum of Natural History
New York, NY

March 2012

Date should be the month and year that the Dissertation Defense Approval form was signed

there should be NO page number for title page

Sample Formatting for Copyright Page *(Optional)*

Begin the copyright notice approximately one-third of the way down the page, centered, with no terminal punctuation. Provide only the year the dissertation was completed, matching the year on the Title Page; the author name should be identical to how it appears on the Title Page

Begin pagination with Roman number "ii", and continue consecutive numbering for all front matter

Sample Formatting for Abstract Page *(Required)*

THIS IS HOW THE TITLE OF YOUR DOCTORAL DISSERTATION SHOULD APPEAR ON THE ABSTRACT

John A. Doe, M.S.

Chair: Jane A. Smith, Ph.D.

ABSTRACT

The text of the abstract for the entire dissertation should appear here, double-spaced, with no word limit but suggested to be no more than 350 words, utilizing standard paragraph indentation.

The highest degree only of the author (student) and the name of the Dissertation Committee Chair (advisor) should be indicated after the author name

Spacing may be triple space, but not double/double (quadrapuple) space between Chair's name and Abstract heading

Title and student's name must be identical to how they appear on the Title Page

Titles: Small caps; capitalize the first letter of each word, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

Sample Formatting for Dedication Page *(Optional)*

The dedication should appear here,
centered, single-spaced, and italicized

Begin the dedication approximately one-third of the way down the page, with no terminal punctuation

You may, but need not, include a header, such as "Dedication" or "Dedicated."
You may simple identify the person or persons to whom you are dedicating the work (e.g., "To my parents, Jane and John Doe")

It is recommended that you avoid extravagant or humorous dedications

Sample Formatting for Acknowledgements Page *(Optional)*

ACKNOWLEDGEMENTS

The text of the dissertation acknowledgements should appear here, double-spaced, utilizing standard paragraph indentation.

Titles: Small caps; capitalize the first letter of each word, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

Sample Formatting for Epigraph Page *(Optional)*

The epigraph quote, if included in the dissertation, should appear here, single-spaced, centered.

– Epigraph author's name

Begin the epigraph approximately one-third of the way down the page

Do not enclose it in quotation marks. Do not include a header, such as "Epigraph."

Double-space between the text of the epigraph and the name of the author of the epigraph; the author's name should be preceded by a dash

Match this format exactly including punctuation, capitalization, etc.
Use the small caps function in the font settings for the entire ToC.
Capitalize the first letter of each word in all entries, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

TABLE OF CONTENTS

Sample Formatting for List of Figures, Tables, and Illustrations *(Optional)*

FIGURES, TABLES, AND ILLUSTRATIONS

Titles: Small caps; capitalize the first letter of each word, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

Figures

note: [chapter - figure number] format; no other punctuation. Applies to tables and illustrations also

Tables

Illustrations

If there are substantial numbers of items in any of these categories, each category may be listed on separate pages.

If the student is the creator of the figure, table, or illustration, the title of the item alone will suffice; however, if the student is using a figure, table, or illustration created by another, the name of the individual and the publication from which the item was derived should also be included.

Turabian/Chicago Style List of Tables or Figures

Chicago Style TURABIAN
List of Tables or Figures

Put the list in the front matter after the contents page.

Place the title Tables (or Figures) at the top of the first page, centered.

Tables

Leave two blank lines between the title and the first item.

Align table (or figure) numbers at the left margin.

Table (or figure) titles may be shortened for the list.

Single-space each item, and add a blank line between items.

Use the same tab stop for each title.

Place page numbers flush right, with leader dots if you wish.

Sample Formatting for List of Abbreviations (Optional)

ABBREVIATIONS

AMNH	American Museum of Natural History
JAMA	Journal of the American Medical Association
n. gen.	new genus
NSF-DDIG	National Science Foundation-Doctoral Dissertation Improvement Grant
n. sp.	new species
RGGS	Richard Gilder Graduate School

Entries should be listed alphabetically; double-space between entries.

Sample Formatting for Glossary *(Optional)*

GLOSSARY

biogeography. The study of the distribution of species (biology), organisms, and ecosystems in space and through geological time.

helminth. A worm classified as a parasite.

microsatellite. A repeating sequence in DNA.

phylogeography. The study of the historical processes that may be responsible for the contemporary geographic distributions of individuals.

spaced

Entries should be listed alphabetically; double-space between entries, but single ~~species~~ within individual entries if they carry over to more than one line

Sample Formatting for Preface (Optional)

PREFACE

The text of the Preface to the dissertation should begin here, double-spaced, utilizing standard paragraph indentation.

Begin pagination with Arabic number "1",
and continue consecutive numbering for the remainder of the ENTIRE manuscript,
INCLUDING appendices

CHAPTER I

DIRECT OPTIMIZATION, SENSITIVITY ANALYSIS, AND THE EVOLUTION OF THE HYMENOPTERAN SUPERFAMILIES

Commented [BK3]: Chapter I is small caps, as is the title of the Chapter. All bold. Capitalize the first letter of all words except for articles, prepositions, or coordinating conjunctions such as in, the, a, of...

Abstract

Commented [BK4]: Abstract in regular font, bold, centered. Capitalize first letter of all words except articles, prepositions, or coordinating conjunctions

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Introduction

Commented [BK5]: Introduction in regular font, bold, centered; see below for other types of subchapter headers

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Materials and Methods

Commented [BK6]: Often after the Introduction, there is a section for Materials and Methods – use regular font, bold, and center

Taxa and characters

Commented [BK7]: A new heading such as this within a section should appear left justified, regular font, italicized. Only first word is Capitalized unless it's a proper noun

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Phylogenetic analyses

Commented [BK8]: You might have several subheadings under a section. Continue to use this style.

Your text starts here, with a paragraph indent. Then continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues, continues.

Results

Commented [BK9]: Results is another common section. Should appear centered, regular type, bold

Your text starts here, with a paragraph indent. Then continues, continues, continues,

Commented [BK10]: Remember to be leaving 1.25" at the bottom; page number s/b .75" from the bottom

Sample Formatting for Text page
with footnotes

CHAPTER I

TITLE OF CHAPTER

Titles: Small caps; Capitalize the first letter of each word, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

> An optional chapter epigraph may appear here, with the text of the epigraph single-spaced and fully indented.
>
> – Epigraph Author's Name

The text should begin here, double-spaced throughout, utilizing standard paragraph indentation. Please note that this chapter example is for a traditional, narrative-format chapter *only*. It is encouraged that all chapters be formatted as if they were going to be published as separate papers (unless the bulk of the dissertation is written as a "traditional narrative" dissertation), and should include an abstract, introduction, etc.

Section Title

(Section Titles are optional; if used, maintain double-spacing)

The text should begin here, double-spaced throughout, utilizing standard paragraph indentation.

> All quotations should be fully indented, single-spaced, and appropriately referenced with a footnote.[1]

The regular text should continue here, resuming double-spacing. Here is a sample standard footnote where a hard copy of the journal was accessed.[2] This is a sample of a footnote for a journal article accessed electronically.[3]

---

[1] Footnotes should appear here in appropriate format, preceded by a partial solid line, at the bottom of each page.

[2] C.J. Underwood, A. Goswami, G.V.R. Prasad, O. Verma, and J.J. Flynn, "Marine Vertebrates From the 'Middle' Cretaceous (early Cenomanian) of South India," *Journal of Vertebrate Paleontology,* vol. 31, no. 3 (2011): 541.

[3] J.J. Flynn, S. Nesbitt, J.M. Parrish, L. Ranivoharimanana, and A. R. Wyss, "A New Species of *Azendohsaurus* (Diapsida: Archosauromorpha) from the Triassic Isalo Group of Southwestern Madagascar:

The Chicago Manual of Style *Online*

Chicago Style In-text Citations

Author-Date: Sample Citations

Go to Notes and Bibliography: Sample Citations

The following examples illustrate the author-date system. Each example of a reference list entry is accompanied by an example of a corresponding in-text citation. For more details and many more examples, see chapter 15 of *The Chicago Manual of Style*. For examples of the same citations using the notes and bibliography system, follow the Notes and Bibliography link above.

Book

Reference list entries (in alphabetical order)

Grazer, Brian, and Charles Fishman. 2015. *A Curious Mind: The Secret to a Bigger Life*. New York: Simon & Schuster.
Smith, Zadie. 2016. *Swing Time*. New York: Penguin Press.

In-text citations

(Grazer and Fishman 2015, 12)
(Smith 2016, 315–16)

For more examples, see 15.40–45 in *The Chicago Manual of Style*.

Chapter or other part of an edited book

In the reference list, include the page range for the chapter or part. In the text, cite specific pages.

Reference list entry

Thoreau, Henry David. 2016. "Walking." In *The Making of the American Essay*, edited by John D'Agata, 167–95. Minneapolis: Graywolf Press.

In-text citation

(Thoreau 2016, 177–78)

In some cases, you may want to cite the collection as a whole instead.

Reference list entry

D'Agata, John, ed. 2016. *The Making of the American Essay*. Minneapolis: Graywolf Press.

In-text citation

(D'Agata 2016, 177–78)

For more details, see 15.36 and 15.42 in *The Chicago Manual of Style*.

Translated book

Reference list entry

Lahiri, Jhumpa. 2016. *In Other Words*. Translated by Ann Goldstein. New York: Alfred A. Knopf.

In-text citation

(Lahiri 2016, 146)

E-book

For books consulted online, include a URL or the name of the database in the reference list entry. For other types of e-books, name the format. If no fixed page numbers are available, cite a section title or a chapter or other number in the text, if any (or simply omit).

Reference list entries (in alphabetical order)

Austen, Jane. 2007. *Pride and Prejudice*. New York: Penguin Classics. Kindle.

Borel, Brooke. 2016. *The Chicago Guide to Fact-Checking*. Chicago: University of Chicago Press. ProQuest Ebrary.

Kurland, Philip B., and Ralph Lerner, eds. 1987. *The Founders' Constitution*. Chicago: University of Chicago Press. http://press-pubs.uchicago.edu/founders/.

Melville, Herman. 1851. *Moby-Dick; or, The Whale*. New York: Harper & Brothers. http://mel.hofstra.edu/moby-dick-the-whale-proofs.html.

In-text citations

(Austen 2007, chap. 3)
(Borel 2016, 92)
(Kurland and Lerner 1987, chap. 10, doc. 19)
(Melville 1851, 627)

Journal article

In the reference list, include the page range for the whole article. In the text, cite specific page numbers. For articles consulted online, include a URL or the name of the database in the reference list entry. Many journal articles list a DOI (Digital Object Identifier). A DOI forms a permanent URL that begins https://doi.org/. This URL is preferable to the URL that appears in your browser's address bar.

Reference list entries (in alphabetical order)

Keng, Shao-Hsun, Chun-Hung Lin, and Peter F. Orazem. 2017. "Expanding College Access in Taiwan, 1978–2014: Effects on Graduate Quality and Income Inequality." *Journal of Human Capital* 11, no. 1 (Spring): 1–34. https://doi.org/10.1086/690235.

LaSalle, Peter. 2017. "Conundrum: A Story about Reading." *New England Review* 38 (1): 95–109. Project MUSE.

Satterfield, Susan. 2016. "Livy and the *Pax Deum*." *Classical Philology* 111, no. 2 (April): 165–76.

In-text citations

(Keng, Lin, and Orazem 2017, 9–10)
(LaSalle 2017, 95)
(Satterfield 2016, 170)

Journal articles often list many authors, especially in the sciences. If there are four or more authors, list up to ten in the reference list; in the text, list only the first, followed by *et al*. ("and others"). For more than ten authors (not shown here), list the first seven in the reference list, followed by et al.

Reference list entry

Bay, Rachael A., Noah Rose, Rowan Barrett, Louis Bernatchez, Cameron K. Ghalambor, Jesse R. Lasky, Rachel B. Brem, Stephen R. Palumbi, and Peter Ralph. 2017. "Predicting Responses to Contemporary Environmental Change Using Evolutionary Response Architectures." *American Naturalist* 189, no. 5 (May): 463–73. https://doi.org/10.1086/691233.

In-text citation

(Bay et al. 2017, 465)

For more examples, see 15.46–49 in *The Chicago Manual of Style*.

News or magazine article

Articles from newspapers or news sites, magazines, blogs, and the like are cited similarly. In the reference list, it can be helpful to repeat the year with sources that are cited also by month and day. Page numbers, if any, can be cited in the text but are omitted from a reference list entry. If you consulted the article online, include a URL or the name of the database.

Reference list entries (in alphabetical order)

Manjoo, Farhad. 2017. "Snap Makes a Bet on the Cultural Supremacy of the Camera." *New York Times*, March 8, 2017. https://www.nytimes.com/2017/03/08/technology/snap-makes-a-bet-on-the-cultural-supremacy-of-the-camera.html.
Mead, Rebecca. 2017. "The Prophet of Dystopia." *New Yorker*, April 17, 2017.
Pai, Tanya. 2017. "The Squishy, Sugary History of Peeps." *Vox*, April 11, 2017. http://www.vox.com/culture/2017/4/11/15209084/peeps-easter.
Pegoraro, Rob. 2007. "Apple's iPhone Is Sleek, Smart and Simple." *Washington Post*, July 5, 2007. LexisNexis Academic.

In-text citation

(Manjoo 2017)
(Mead 2017, 43)
(Pai 2017)
(Pegoraro 2007)

Readers' comments are cited in the text but omitted from a reference list.

In-text citation

(Eduardo B [Los Angeles], March 9, 2017, comment on Manjoo 2017)

For more examples, see 15.49 (newspapers and magazines) and 15.51 (blogs) in *The Chicago Manual of Style*.

Book review

Reference list entry

Kakutani, Michiko. 2016. "Friendship Takes a Path That Diverges." Review of *Swing Time*, by Zadie Smith. *New York Times*, November 7, 2016.

In-text citation

(Kakutani 2016)

Interview

Reference list entry

Stamper, Kory. 2017. "From 'F-Bomb' to 'Photobomb,' How the Dictionary Keeps Up with English." Interview by Terry Gross. *Fresh Air*, NPR, April 19, 2017. Audio, 35:25. http://www.npr.org/2017/04/19/524618639/from-f-bomb-to-photobomb-how-the-dictionary-keeps-up-with-english.

In-text citation

(Stamper 2017)

Thesis or dissertation

Reference list entry

Rutz, Cynthia Lillian. 2013. "*King Lear* and Its Folktale Analogues." PhD diss., University of Chicago.

In-text citation

(Rutz 2013, 99–100)

Website content

It is often sufficient simply to describe web pages and other website content in the text ("As of May 1, 2017, Yale's home page listed . . ."). If a more formal citation is needed, it may be styled like the examples below. For a source that does not list a date of publication or revision, use ***n.d.*** (for "no date") in place of the year and include an access date.

Reference list entries (in alphabetical order)

Bouman, Katie. 2016. "How to Take a Picture of a Black Hole." Filmed November 2016 at TEDxBeaconStreet, Brookline, MA. Video, 12:51. https://www.ted.com/talks/katie_bouman_what_does_a_black_hole_look_like.
Google. 2017. "Privacy Policy." Privacy & Terms. Last modified April 17, 2017. https://www.google.com/policies/privacy/.
Yale University. n.d. "About Yale: Yale Facts." Accessed May 1, 2017. https://www.yale.edu/about-yale/yale-facts.

In-text citations

(Bouman 2016)
(Google 2017)
(Yale University, n.d.)

For more examples, see 15.50–52 in *The Chicago Manual of Style*. For multimedia, including live performances, see 15.57.

Social media content

Citations of content shared through social media can usually be limited to the text (as in the first example below). If a more formal citation is needed, a reference list entry may be appropriate. In place of a title, quote up to the first 160 characters of the post. Comments are cited in reference to the original post.

Text

Conan O'Brien's tweet was characteristically deadpan: "In honor of Earth Day, I'm recycling my tweets" (@ConanOBrien, April 22, 2015).

Reference list entries (in alphabetical order)

Chicago Manual of Style. 2015. "Is the world ready for singular they? We thought so back in 1993." Facebook, April 17, 2015. https://www.facebook.com/ChicagoManual/posts/10152906193679151.
Souza, Pete (@petesouza). 2016. "President Obama bids farewell to President Xi of China at the conclusion of the Nuclear Security Summit." Instagram photo, April 1, 2016. https://www.instagram.com/p/BDrmfXTtNCt/.

In-text citations

(Chicago Manual of Style 2015)
(Souza 2016)
(Michele Truty, April 17, 2015, 1:09 p.m., comment on Chicago Manual of Style 2015)

Personal communication

Personal communications, including email and text messages and direct messages sent through social media, are usually cited in the text only; they are rarely included in a reference list.

In-text citation

(Sam Gomez, Facebook message to author, August 1, 2017)

Titles: Capitalize the first letter of each word, except for articles, prepositions, or coordinating conjunctions such as a, the, of, to, etc.

CHAPTER II

A NEW SPECIES OF *AZENDOHSAURUS* (DIAPSIDA: ARCHOSAUROMORPHA) FROM THE TRIASSIC ISALO GROUP OF SOUTHWESTERN MADAGASCAR: CRANIUM AND MANDIBLE

Abstract

If a chapter is comprised of a published journal article, it is recommended that a brief preface or introduction be provided. This journal article itself would appear on the next page, following the preface or introduction to the article. In this example, the sample of the journal article immediately follows this page.

You will note in the example that follows, the journal article has been sized to fit within the required margins for the dissertation. The top and right-hand margin are each one inch (1.00") from the edge of the paper to the edge of article; the left-hand margin is one and one-half inches (1.50") from the edge of the paper to the left edge of the article; and the bottom margin is one and one-quarter (1.25") inches from the edge of the paper to the bottom edge of the article. You will also note that the original journal article page number is retained; however, the consecutive pagination for the dissertation is maintained, with the appropriate consecutive page number spaced three-quarters of an inch (0.75") from the bottom edge of the paper.

Cranium and Mandible," *Palaeontology* vol. 53, part 3 (2010): 671, http://onlinelibrary.wiley.com/doi/10.1111/j.1475-4983.2010.00954.x/abstract.

Palaeontology The Palaeontological Association www.palass.org

[Palaeontology, Vol. 53, Part 3, 2010, pp. 669–688]

A NEW SPECIES OF *AZENDOHSAURUS* (DIAPSIDA: ARCHOSAUROMORPHA) FROM THE TRIASSIC ISALO GROUP OF SOUTHWESTERN MADAGASCAR: CRANIUM AND MANDIBLE

by JOHN J. FLYNN*, STERLING J. NESBITT*†‡, J. MICHAEL PARRISH§, LOVASOA RANIVOHARIMANANA¶ *and* ANDRÉ R. WYSS**

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§College of Science, San Jose State University, One Washington Square, San Jose, CA 95192, USA; e-mail mparrish@science.sjsu.edu
¶Département de Paléontologie et d'Anthropologie Biologique, Université d'Antananarivo, Antananarivo, Madagascar; e-mail ranivolova@moov.mg
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Typescript received 12 January 2009; accepted in revised form 26 July 2009

Abstract: Here, we describe a new species of *Azendohsaurus* from the Middle–Late Triassic of Madagascar, extending the geographical range of a taxon known otherwise only by a single species from Morocco. Although *Azendohsaurus* has consistently been regarded as an early dinosaur (based on various advanced dental and gnathic features resembling those characterizing certain dinosaur subgroups), the relatively complete skeletal material, now available from Madagascar, argues strongly against its dinosaurian affinities. Rather, the retention of numerous primitive cranial and postcranial features indicates a surprisingly early divergence of *Azendohsaurus* within Archosauromorpha and an unusual mosaic of characters in this taxon. Features considered diagnostic of Sauropodomorpha thus are inferred to occur homoplastically in at least one clade of nondinosaurian archosauromorphs, indicating a complex evolution and distribution of features traditionally thought to be derived within archosaurs. *Azendohsaurus* has teeth resembling those of both early sauropodomorph and ornithischian dinosaurs, yet also possesses numerous inarguable basal archosauromorph cranial and postcranial attributes. This highlights the risk of uncritically referring isolated, Middle–Late Triassic (or even later), 'leaf-shaped' teeth with denticles to the Dinosauria. Similarly, the occurrence of such teeth in an early diverging archosauromorph indicates that specializations for herbivory originated more frequently within this clade than conventionally assumed. For example, *Azendohsaurus* and numerous basal sauropodomorph dinosaur taxa share an array of convergently acquired features associated with herbivory, including tooth denticles, expanded tooth crowns, a downturned dentary and the articular located at the ventral margin of the mandible. Some of these features (denticles, expanded crowns and the ventrally deflected articular) are even more widespread among archosauromorphs, including aetosaurs, silesaurs and ornithischian dinosaurs. A downturned dentary also occurs in *Trilophosaurus*, a taxon further marked by unique specializations for herbivory, including transversely lophate, tricuspid teeth. An array of features associated with herbivory also occurs in rhynchosaurs and certain crocodilians (e.g. *Simosuchus*). This distribution suggests that craniodental features associated with herbivory were much more pervasive across the archosauromorph clade than previously recognized, possibly evolving at least six to eight times independently.

Key words: *Azendohsaurus*, Archosauromorpha, Triassic, Madagascar, Isalo Group, herbivory.

AZENDOHSAURUS LAAROUSSII Dutuit, 1972, from the Triassic Argana Formation of Morocco, is characterized by an herbivorously specialized dentition. These include apomorphies present in various herbivorous dinosaurs, which have been shown by our current analysis to have yielded spurious phylogenetic results. Proposed on the basis of gnathic remains, *A. laaroussii* was originally referred to the Ornithischia (Dutuit 1972). Subsequent workers, including Thulborn (1973, 1974), Bonaparte (1976) and Dutuit himself (Dutuit and Heyler 1983, p. 629) considered *A. laaroussii* to be a member of the Prosauropoda, usually in a basal position within the group. Gauffre (1993) also considered *A. laaroussii* to be a nonyunannosaurid prosauropod. In a recent abstract, Jalil and Knoll (2002) mentioned recovery of fragmentary disarticulated postcranial remains from the holotype

 doi: 10.1111/j.1475-4983.2010.00954.x

Directions for References: Include your references at the end of each Chapter, starting on a new page. Single spacing as shown is preferred, with a line space between each reference. List publications alphabetically by author. Multiple publications by the same author or by the same two authors should be ordered chronologically in the following format (unless following the format of the AMNH Style Guide).

References

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Andrews, Timothy J., Scott D. Halpern, and Dale Purves. 1997. "Correlated size variations in human visual cortex, lateral geniculate nucleus, and optic tract." *The Journal of Neuroscience* 17(8): 2859-2868.

Balanoff, Amy. 2011. *Oviraptorosauria: Morphology, Phylogeny, and Endocranial Evolution*. Ph. D. Dissertation. Columbia University.

Balanoff, Amy M., Gabe S. Bever, Timothy B. Rowe, Mark A. Norell. 2014. "Evolutionary origins of the avian brain." *Nature* 501(7465): 93-96.

Bruehlmeier, Matthias, Barbara Kaser-Hotz, Roger Achermann, Carla Rohrer Bley, Melanie Wergin, Pius A. Schubiger, and Simon M. Ametamey. 2005. "Measurement of tumor hypoxia in spontaneous canine sarcomas." *Veterinary Radiology and Ultrasound* 46(4):348-354.

Carey, James R. and Justin Adams. 2001. "The preadaptive role of parental care in the evolution of avian flight." *Archaeopteryx* 19:97-108.

Casteels, Cindy, Peter Vermaelen, Johan Nuyts, Annemie Van Der Linden, Veerle Baekelandt, Luc Mortelmans, Guy Bormans, and Koen Van Laere. 2006. "Construction and evaluation of multitracer small-animal PET probabilistic atlases for voxel-based functional mapping of the rat brain." *Journal of Nuclear Medicine* 47:1858-1866.

Chai, C.Y., Wang, S.C. 1962. "Localization of central cardiovascular control mechanism in lower brain stem of the cat." *American Journal of Physiology* 202(1): 25-30.

Chen, Pei-ji, Zhi-ming Dong, and Shuo-nan Zhen. 1998. "An exceptionally well-preserved theropod dinosaur from the Yixian Formation of China." *Nature* 391(6663): 147–152.

Cossar Ewart, J. 1921. The nestling feathers of the mallard, with observations on the composition, origin, and history of feathers. *Proceedings of the Zoological Society of London:* 609–642.

Crompton, A.W. and Pamela Parker. 1978. "Evolution of the mammalian masticatory apparatus: the fossil record shows how mammals evolved both complex chewing mechanisms and an effective middle ear, two structures that distinguish them from reptiles." *American Scientist* 66(2): 192-201.

There should be no spaces between author initials: A.B NOT A. B.

Double space between entries

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Example AMNH Style References

Lopatin, A.V., and P.E. Kondrashov. 2004. Sarcodontinae, a new subfamily of micropternodontid insectivores from the early Paleocene–middle Eocene of Asia. Bulletin of New Mexico Museum of Natural History and Science 26: 177–184.

Luo, Z.X., and E.R. Eastman. 1995. Petrosal and inner ear of a squalodontoid whale: implications for evolution of hearing in *Odontosetes*. Journal of Vertebrate Paleontology 15: 431–442.

MacPhee, R.E.E., and M.D. Novacek. 1993. Definition and relationships of Lipotyphla. *In* F.S. Szalay, M.D. Novacek, and M.C. McKenna (editors), Mammal phylogeny: placentals: 13–31. New York: Springer-Verlag.

Maddison, D.R., and W.P. Maddison. 2005. MacClade 4: analysis of phylogeny and character evolution. Version 4.08a. Sunderland, MA: Sinauer Associates.

Maddison, W.P., and D.R. Maddison. 2018. Mesquite: a modular system for evolutionary analysis. Version 3.51. [http://www.mesquiteproject.org]

Marsh, O.C. 1889. Discovery of Cretaceous Mammalia. American Journal of Science S3-38: 81–92.

Matthew, W.D. 1901. Additional observations on the Creodonta. Bulletin of the American Museum of Natural History 14 (1): 1–38.

Matthew, W.D. 1903. The fauna of the *Titanotherium* beds at Pipestone Springs, Montana. Bulletin of the American Museum of Natural History 19 (6): 197–226.

Matthew, W.D. 1909. The Carnivora and Insectivora of the Bridger Basin, Middle Eocene. Memoirs of the American Museum of Natural History 9 (6): 291–576.

Matthew, W.D. 1913. A zalambdodont insectivore from the basal Eocene. Bulletin of the American Museum of Natural History 32 (17): 307–314.

Matthew, W.D., and W. Granger. 1925. Fauna and correlation of the Gashato Formation of Mongolia. American Museum Novitates 189: 1–12.

Matthew, W.D., W. Granger, and G.G. Simpson. 1929. Additions to the fauna of the Gashato Formation of Mongolia. American Museum Novitates 376:1–12.

McDowell, S.B. 1958. The Greater Antillean insectivores. Bulletin of the American Museum of Natural History 115 (3): 117–214.

McKay, C. J., et al. 2022. Dental development and first premolar homology in placental mammals. Vertebrate Zoology 72: 201–208.

McKenna, M.C. 1963. New evidence against the tupaioid affinities of the mammalian family Anagalidae. American Museum Novitates 2158: 1–16.

McKenna, M.C. 1968. *Leptacodon*, an American Paleocene nyctithere (Mammalia, Insectivora). American Museum Novitates 2317: 1–12.

McKenna, M.C., and S.K. Bell, 1997. Classification of Mammals, above the species level, with contributions from G.G. Simpson, R.H. Nichols, R.H. Tedford, K.E. Koopman, G.G Musser, N.A. Neff, J. Shoshani, D.M. McKenna. New York: Columbia University Press, 547 pp.

McKenna, M.C., X.X. Xue, and M.Z. Zhou. 1984. *Prosarcodon lonanensis*, a new Paleocene micropternodontid Palaeoryctoid insectivore from Asia. American Museum Novitates 2780: 1–17.

Meng, J., R.-j. Zhai, and A.R. Wyss. 1998. The late Paleocene Bayan Ulan fauna of Inner Mongolia, China. In K.C. Beard, and M.R. Dawson (editors), Dawn of the age of mammals in Asia. Bulletin of Carnegie Museum of Natural History 34: 148–185.

Meng, J., Y.M. Hu, and C.K. Li. 2003. The osteology of *Rhombomylus* (Mammalia, Glires): implications for phylogeny and evolution of Glires. Bulletin of the American Museum of Natural History 275: 1–245.

Meredith, R.W., et al. 2011. Impacts of the Cretaceous terrestrial revolution and KPg extinction on mammal diversification. Science 334: 521–524.

Miller, M.E. 1964. Anatomy of the dog. Philadelphia: W.B. Saunders Company, 544 pp.

Missiaen, P., and T. Smith. 2005. A new Paleocene nyctitheriid insectivore from Inner Mongolia (China) and the origin of Asian nyctitheriids. Acta Plaeontologica Polonica 50: 513–522.

Moore, W.J. 1981. The mammalian skull. New York: Cambridge University Press, 369 pp.

Nessov, L.A. 1987. Results of search and investigation of Cretaceous and early Paleogene mammals on the territory of the USSR. Ezhegodnik Vsesoyuznogo Paleontologicheskogo Obshchestva 30: 199–218.

Ni, X.J., Y.Q. Wang, Y.M. Hu, and C.K. Li. 2004. A euprimate skull from the early Eocene of China. Nature 427: 65–68.

Novacek, M.J. 1986. The skull of leptictid insectivorans and the higher-level classification of eutherian mammals. Bulletin of the American Museum of Natural History 183: 1–111.

O'Leary, M.A., et al. 2013. The placental mammal ancestor and the post–K-Pg radiation of placentals. Science 339: 662–667.

Qi, T., 1987. The middle Eocene Arshanto fauna (Mammalia) of Inner Mongolia. Annals of Carnegie Museum 56: 1–73.

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For complete information on how to format tables and figures, please refer to the *Chicago Manual of Style, 16th ed.*

WHY USE TABLES & FIGURES[1(pp.112, 127, 133)]

- Tables and figure emphasize, or explain key information in your assignment
- They display data by summarizing, organizing, and condensing information
- Tables and figures add visual appeal to your assignment, if used properly
- Tables and figures act as supplementary material, and should not duplicate information written in-text

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CHICAGO STYLE TABLES & FIGURES IN-TEXT[1(pp. 116-118, 135)]

- Discuss the main points of the table or figure in the body of your written assignment
- Number tables and figures in-text with Arabic numerals:
  Example: As shown in table 1….
  As figure 1 shows…
- Number tables and figures in consecutive order as they appear in your assignment
  Note: See pp. 118-119 for exception
- If your assignment contains both tables and figures, number them separately
  Example: table 1, table 2, figure 1, figure 2

HOW TO FORMAT FIGURES IN CHICAGO STYLE[1(pp. 112-132)]

Figure 1: Map of the city of Toronto in Canada. "Toronto, Canada." Google Maps, Accessed May 26, 2015, https://www.google.ca/maps.

List figure number

Display figure citation in the caption

- Position the figure within the body of your assignment
- Use a legend to explain any symbols displayed in the figure if required
- Use a caption, typically located below the illustration, to explain the figure
- The caption may consist of words, or full-sentences
- Include citation information in the caption after an explanation of the figure
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HOW TO FORMAT TABLES IN CHICAGO STYLE[1](pp. 135-154)

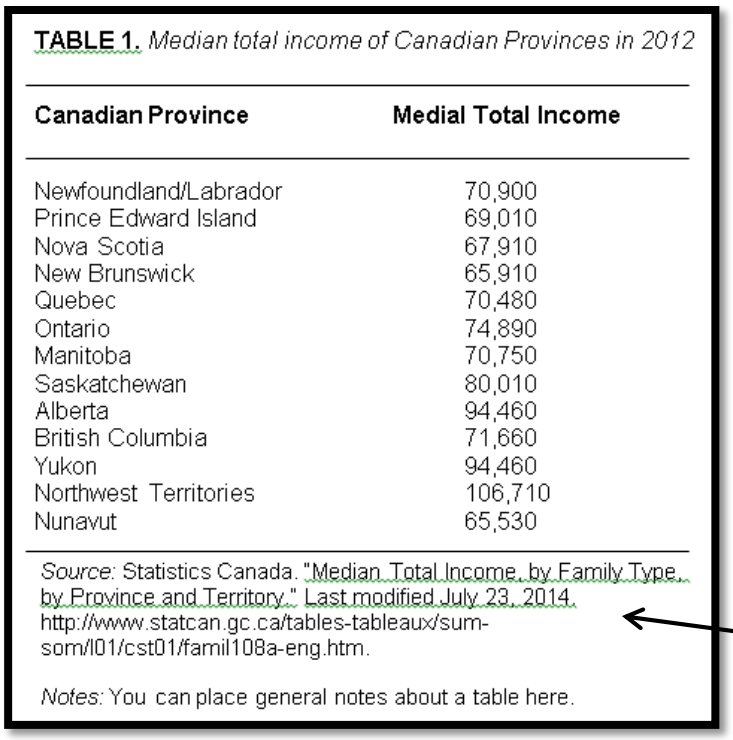

TABLE 1. *Median total income of Canadian Provinces in 2012*

Canadian Province	Medial Total Income
Newfoundland/Labrador	70,900
Prince Edward Island	69,010
Nova Scotia	67,910
New Brunswick	65,910
Quebec	70,480
Ontario	74,890
Manitoba	70,750
Saskatchewan	80,010
Alberta	94,460
British Columbia	71,660
Yukon	94,460
Northwest Territories	106,710
Nunavut	65,530

Source: Statistics Canada. "Median Total Income, by Family Type, by Province and Territory." Last modified July 23, 2014. http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil108a-eng.htm.

Notes: You can place general notes about a table here.

Display table citation in the footnote

- Position the table in the body of your assignment
- Arrange data in columns and rows
- Give your table a brief, but descriptive title, and label number ***RGGS--title AT TOP***
- Each column in a table must have a heading
- Cite sources in the footnotes section of the table (see below for information about note types)
- Follow the *Chicago Manual of Style* guidelines to format citations in the footnote

HOW TO FORMAT TABLE NOTES IN CHICAGO STYLE[1](pp.146-150)

- Use notes to provide the reader with more information about the table
- Write notes in complete sentences, or short phrases. There are four types of table notes:
    - **Source notes:** Place citation information for sources used in the table in a source note. Begin the note with the "*Source:*" in italics followed by the citation. Provide the full citation if it's not listed in your reference list. Provide a brief citation if you list the source in your references:
        - ***Example of brief citation:*** Data from Smith and Williams (2011).
    - **Whole table notes:** Contain information about the entire table. Start whole table notes with "*Note:*" in italics.
    - **Specific notes:** Use superscript letters, numbers, or symbols to signify notes about specific parts of the table. See page 148 of the *Chicago Manual of Style* for more information about specific notes.
    - **Probability notes:** Indicates how symbols like the asterisk are used in a table. See page 148-149 of the *Chicago Manual of Style* for more information about probability notes.
- Notes appear in table footnotes in the order as shown above.

[1]University of Chicago Press. *The Chicago Manual of Style*. 16th ed. Chicago: University of Chicago Press, 2010.

Sample Formatting for Appendix Title page (Typically Required)

APPENDIX A:

APPENDIX TITLE

Each appendix should be preceded by an Appendix Title Page

Begin the appendix title page approximately one-third of the way down the page, centered

Appendix E.

Supplementary Data File

Description:

The accompanying Excel spreadsheet shows the events simulated and prediction results. In the column headings of each sheet: “Barnacle” represents running Barnacle with default filter settings; “Barnacle-MM” represents running Barnacle without filtering multi-mapping contigs; “BWA” or “ABySS-map” denotes the tool used to align reads to contig sequences.

Filename:

SwansonLucas_simulated_events.xls

Example of how to include data files in thesis.

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[Date]

[Name and address of addressee]

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I am completing a doctoral dissertation at the Richard Gilder Graduate School at the American Museum of Natural History entitled "_____," with an anticipated publication date of [month, year]. I would like your permission to reprint in my dissertation [excerpts from the following/the following in it's entirety as originally published]:

> [Insert full citation and description of the original work.]
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The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages, and to prospective publication of my dissertation by ProQuest through its UMI® Dissertation Publishing business. ProQuest may produce and sell copies of my dissertation on demand and may make my dissertation available for free internet download at my request. These rights will in no way restrict republication of the material in any other form by you or by others authorized by you. Your signing of this letter will also confirm that you own [or your company owns] the copyright to the above-described material[s]. If you are [or your company is] not the copyright holder, or if additional permission is needed from another source, please indicate so.

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Sincerely,

[Your name and signature]

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

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Declarations

Acknowledgements: We would like to thank George Barrowclough, Jonas Lai, and Joel Cracraft from the American Museum of Natural History and Jack Withrow and Kevin Winker from the University of Alaska Museum of the North for logistical help and assistance with sampling for this study. Lukas Musher provided valuable feedback on the manuscript. We thank Brynn Parr of the Alaska Department of Fish and Game for assistance with acquiring collecting permits.

Funding: This work was supported by the REU biology program at the American Museum of Natural History (NSF Award 1358465), the Theodore Roosevelt Memorial Fund from the American Museum of Natural History, the Society of Systematic Biologists graduate student research award, and the Explorer's Club student grant. The funding sources had no role in design, implementation, or writing of the study.

Availability of data and materials: Genetic data is available through GenBank (accession numbers: MG946320-MG946383, MG946384-MG946450, MG946451-MG946505, MG946506-MG946572, MG946573-MG946614, MG946615-MG946674, MG946675-MG946714). Alignments, tree topologies, host specificity data, and R code for analyses is available at:

https://github.com/sgalen/Leucocytozoon_Species_Delimitation_2018

Authors' contributions: SCG and SLP designed the study. SCG and PRS collected samples. SCG and RN performed lab work. SCG wrote the manuscript, which was read and edited by all authors. All authors have read and approved the final manuscript.

Ethics approval and consent to participate: Birds were collected under State of Alaska Department of Fish and Game Scientific Permits 16-013 and 17-092 and approved by the Institutional Animal Care and Use Committee of the American Museum of Natural History.

Consent for publication: Not applicable

Competing interests: The authors declare that they have no competing interests

[Placed below chapter text and above chapter references]

References

Contents

APPENDIX A: SUPPLEMENTARY MATERIALS FOR CHAPTER II

Appendix 2.1: Supplementary Analyses and Results

I classified taxa into categories based on published elevational ranges: desert lowland, highland montane, or both. I then performed GLMM to predict divergence times based on combinations of 1-3 organismal traits (locomotive, thermoregulatory, elevational), and one of six classification groups (i.e., Genus through Kingdom) as a random effect. Thus, I ran 49 models representing those combinations. Elevation is never a significant predictor of divergence time in any model, before or after accounting for taxonomy. Before accounting for taxonomy, thermoregulation and locomotion are significant irrespective of elevation. However, models accounting for both thermoregulation and locomotion simultaneously are never significant. The models that are significant before accounting for taxonomy remain significant when Genus, Family, Phylum, or Kingdom ranks are used as the random effect. However, they are not significant when using Order or Class as the random effect. My interpretation of these results is that there are too many Genera and Families relative to data points, and too few Phyla and Kingdoms, to act as effective random effects. Therefore, this shows evidence

that thermoregulation and locomotion are not significant after accounting for taxonomic levels.

Appendix 2.2: SLiM Simulation Details

For each of the 32 model sets, I ran 1,000-1,200 simulations each in SLiM 3 with the exception of the eight models run for 1,000,000 generations. These longer models were computationally intense, and so I only ran them 100 times each to determine whether the patterns I found for 6,000-120,000 generations would continue to hold for longer time periods. Scripts are available at github.com/kaiyaprovost.

I used a mutation rate of 2.21 x 10^{-9} substitutions per site per year (Nam et al., 2000), the suggested default recombination rate in SLiM 3.1, and empirical estimates of ancestral population sizes for a bird with genetic structure across the CFB (Provost et al., 2018). I chose a large gene flow value of 10% to amplify the effects of introgression within applicable models. I simulated a chromosome of 100,000 base pairs. For models with a phylogeographic split, I divided individuals into two equally sized populations. The spatial boundaries of these populations were constrained by longitude to simulate a barrier; individuals in population 1 were only able to occupy the western 50% of habitat, and individuals in population 2 were only able to occupy the eastern 50% (see below).

The niche model was constrained to be between longitude -115.70 to -101.26, and latitude 27.00 to 36.47, narrowing in on the transition zone between the deserts. Fitness across the landscape was calculated by taking the cube root of the cell value (which ranged from 0–1) and multiplying it by the relative fitness of the individual; these fitness values are required in SLiM to create new individuals each generation and cause the algorithm to preferentially generate offspring in regions of high ecological niche

suitability.

I reduced the computational load of my models by scaling my parameters by a factor (lambda) of 0.02, and by implementing tree sequence recording (Haller et al., 2019). Scaling factors reduce the number of generations and number of individuals to simulate but keep the relative mutation rate and recombination rate constant. I chose 0.02 as it improved my performance without impacting the distribution of summary statistics in preliminary runs (see below). Tree sequence recording tracks the true ancestry of every position in the simulated chromosome across individuals rather than explicitly simulating mutations (Haller et al., 2019). Individuals who do not have any descendants are removed. I modeled neutral variation from the tree sequences using my scaled mutation rate, then converted the tree sequences to VCF format (Danecek et al., 2011) and MS format (Stevison, 2014). MS format summarizes the number of segregating sites, the positions with polymorphic sites, and the haplotypes of every individual where a zero indicates the ancestral state and a 1 indicates the derived state. When converting to MS format, I randomly sampled 20 diploid individuals, 10 from the eastern side of the barrier and 10 from the western.

I generated 33 summary statistics originally (Supplementary Table 2.2). Many of these summary statistics are highly correlated with each other. There is some evidence to suggest that neural networks can suffer from multicollinearity issues (Cheng et al., 2018). As such I ran the neural network with all summary statistics as well as with a reduced set that only contained statistics correlated with an absolute R-value less than 0.75. This gave us 11 summary statistics (Supplementary Table 2.2).

Appendix 2.3: Niche Modeling

I got occurrence data for the species *Vireo bellii* by downloading all eBird data in May 2017 (Sullivan et al., 2009). I then supplemented this data with data from GBIF.org (09 October 2017; GBIF Occurrence Download https://doi.org/10.15468/dl.87sdjs), iNaturalist, and VertNet (inaturalist.org, vertnet.org). This was done using custom R scripts that made use of the following packages: raster (Hijmans, 2017), MASS (Venables and Ripley, 2002), spocc (Chamberlain, 2017), rgeos (Bivand and Rundel, 2017), dplyr (Wickham et al., 2017), sp (Pebesma and Bivand, 2005; Bivand et al., 2013), and dismo (Hijmans et al., 2017). I removed duplicate localities. Outliers were detected and removed using a probability density function. After this, I thinned the data using spThin (Aiello-Lammens et al., 2014) at a distance of 10 km to account for spatial autocorrelation in the data. This left us with 1,026 occurrence points for the species.

Climate data used was the WorldClim database (Hijmans et al., 2005). I used all 19 variables, but I constrained the climate data to fall within longitude -115.70 to -101.26 and latitude 27.00 to 36.47. This was the extent for both the background points and the final projections. I then took the climate data and the occurrence data and built an ecological niche model using MaxEnt (Phillips et al., 2006) with ENMeval as a wrapper function for model selection (Muscarella et al., 2014). ENMeval is an R package that optimizes MaxEnt models based on different sets of feature classes and regularization values. Cross-validation was done with the block method using 10,000 background points as pseudo-absences. In particular, I used the linear and linear+quadratic feature classes, as well as regularization values of 0.5, 1, 1.5, 2, 2.5, 3, 3.5, and 4. Models were run for each combination of feature classes and regularization values, and the model with the lowest occurrence point omission rate and highest area under the curve was chosen. The

best model used linear+quadratic feature classes and a regularization value of 0.5, with an AUC of 0.83 and an omission rate of 14.2%. The second-best model also used linear+quadratic features, but had a regularization value of 1.0, an AUC of 0.82, and an omission rate of 22.8%. After the final model was generated and projected back onto the climate data, I converted the suitability values from 0−1 for slim to use and down projected to an ascii of 57 by 87 grid cells.

Appendix 2.4: Machine Learning Details

Our neural network used the LBFGS (Byrd et al., 1995) algorithm as its solver and had an adaptive learning rate, where the rate of learning decreased as the iterations increased. The learning rate was initialized at 0.0001. There were 1,000 maximum iterations allowed. The hidden layer was constrained to be three layers each of 100 nodes, which was chosen after testing between it and eight other configurations (one layer of five, 25, or 100 nodes; two layers of five, 25, or 100 nodes; three layers of five, 25, or 100 nodes) to determine which performed best at classifying my validation data. The alpha parameter, which penalizes complexity, was tested across values 0, 0.01, 0.1, 1, and 10; to choose between these, I ran the neural network five times while varying the alpha value, and the network with the highest accuracy was chosen.

Running the neural networks with these values marginally changed my models; they decreased model accuracy across all model runs, improved compute time, and resulted in less overfitting. As such I only present model results using 11 summary statistics unless otherwise specified. In some cases, simulations produced duplicate summary statistic information, in that independent runs of the simulation generated the exact same 33 summary statistics upon output, likely because the same random seed was

generated. I removed these duplicates going forward to avoid overfitting.

Machine learning algorithms have broadly been shown to have high accuracy in classifying models. The suite of tools developed to utilize these algorithms have been used broadly in biological contexts, for example to aid in sound identification (Juang and Chen 2007) and image processing (Wei et al., 2018) as well as for the classification purposes I use them for here (Sukumaran et al., 2016). Despite these strengths, it is not known how well the simulations classify actual genetic data, as that was outside the scope of this study. Further, regardless of how hypotheses are generated and tested, some biological scenarios will still be difficult to tell apart even with powerful and state-of-the-art simulation software and analytical techniques (see main text; Roux et al., 2016).

Appendix 2.5: Supplementary Figures and Tables for Chapter II

Supplementary Table 2.1: Parameters used in the simulated demographic models. Note for my scaled values I used a lambda=0.02. Mutation rate and recombination rate are both per base pair per generation.

Parameter	Original Value	Scaled Value
Effective Population Size (N_E)	400,000	8,000
Mutation Rate	2.21×10^{-9}	1.11×10^{-7}
Recombination Rate	1×10^{-8}	5×10^{-7}
Total Generations	6,000 21,000 120,000 1,000,000	120 420 2,400 20,000
Secondary Contact Generations	1,000	20

Supplementary Table 2.2: Summary statistics used as inputs to my neural network. Asterisks next to variable names indicate that the variable was kept in the 11-statistic, non-collinear dataset.

Variable Name	Description
div_per_site*	Calculated nucleotide diversity per site
fu.li.d*	Fu and Li's D
fu.li.d.1	Above, but calculated assuming two populations
fu.li.f	Fu and Li's F
fu.li.f.1	Above, but calculated assuming two populations
hap.diversity.within*	Haplotype diversity within populations
kurt_haplotype.counts*	Kurtosis of all frequencies of haplotype counts
kurt_minor.allele.freqs	Kurtosis of all minor allele frequencies
mean_haplotype.counts*	Mean of all frequencies of haplotype counts
mean_minor.allele.freqs	Mean of all minor allele frequencies
mean_nuc.diversity.within	Mean of nucleotide diversity within populations
n.biallelic.sites	The number of biallelic sites
n.segregating.sites*	The number of segregating sites in population 1
n.segregating.sites.1	Above, but for population 2
n.sites*	The number of sites total
pi	Nucleotide diversity
skew_haplotype.counts	Skew of all frequencies of haplotype counts
skew_minor.allele.freqs*	Skew of all minor allele frequencies
skew_nuc.diversity.within	Skew of nucleotide diversity within populations
tajima.d	Tajima's D for population 1
tajima.d.1*	Above, but for population 2
theta_achaz.tajima	Achaz's Tajima's D accounting for sequencing error in population 1
theta_achaz.tajima.1*	Above, but for population 2
theta_achaz.watterson	Achaz's Watterson's Theta accounting for sequencing error in population 1
theta_achaz.watterson.1	Above, but for population 2
theta_fu.li	Fu and Li's Theta in population 1
theta_fu.li.1*	Above, but for population 2
theta_tajima	Tajima's Theta
theta_watterson	Watterson's Theta in population 1
theta_watterson.1	Above, but for population 2
var_haplotype.counts	Variance of all frequencies of haplotype counts
var_minor.allele.freqs	Variance of all minor allele frequencies
var_nuc.diversity.within	Variance of nucleotide diversity within populations

Supplementary Table 2.3: Synthesis of previously published phylogeographic studies. Loco = locomotion types (W= walking, J = jumping, F = flying, C = crawling, SM = swimming, SS = sessile). Therm = thermoregulation types (CT = ectotherm, DC = endotherm). Str = structure across CFB (N = no, Y = yes). West and East are most extreme longitudes of contact zones. Time = divergence times (M = Miocene, PL = Pliocene, PS = Pleistocene). GF = gene flow (N = no, Y = yes). Mono = monophyletic or not (N= no, Y = yes). Mode = mode of speciation (A = allopatry, Ecological, S = sexual selection, H = hybridization, P = polyploidy). See footnote for reference numbers.

Taxa	Loco	Therm	Elev	Str	West	East	Time	GF	Mono	Mode	Refs
Agelenopsis aperta	W	CT	D	N			PS				1
Agonum extensicolle	W	CT	D M	Y					Y	A	2
Ammospermophilus complex	W	ND	D	N			PL PS		N		3
Anaxyrus punctatus	J	CT	D	Y	-109.205	-108.857	PS		Y	A	4,5
Antrozous pallidus	F	ND	D M	Y	-109.13	-108.58	PL PS		Y	A	6
Arizona elegans	C	CT	D	Y	-109.5721	-103.75	M PL		Y	E	7,8,9
Auriparus flaviceps	F	ND	D	N				N	N		10,11
Callipepla genus	F	ND	D	Y			PL		Y		12
Campylorhynchus brunneicapillus	F	ND	D	N				N	N		10,11,13
Cardinalis cardinalis	F	ND	D	Y	-108.4975	-103.8765	PS	Y	Y	A	14,15
Certhia americana	F	ND	M	N			PS		N		16
Chaetodipus hispidus	W	ND	D	Y	-108.5	-99.49818	PL		Y	A	17
Chaetodipus intermedius	W	ND	D M	Y			PL PS		Y	A	18,19,20
Chaetodipus penicillatus, C. eremicus	W	ND	D	Y	-108.66	-104.49	PS		Y	A	18,21,22
Colaptes chrysoides, C. auratus	F	ND	D M				PS	Y			10,23,24,25
Corvus corax, C. cryptoleucus	F	ND	D M				PS	Y	N		26,27,28,29, 30,31
Crotalus atrox	C	CT	D				PL	Y	Y	E	7,9,32,33,34
Crotalus molossus	C	CT	M	Y	-112.8209	-103.4542	PL		Y	E	7,9,35
Crotalus scutulatus	C	CT	D	Y	-108.9485	-105.59	PS		Y	E	7,9,36
Crotalus viridis complex	C	CT	M	Y	-111.3753	-106.5556			Y		37,38,39,40
Cucurbita palmata, C. digitata	SS	CT	D M	Y			PS		Y	A	41
Dilophotopsis complex	W	CT	D	Y	-116.3650	-112.905	PL			A	42,43
Dryobates pubescens	F	ND	M	N							10,44,45,46
Dryobates villosus	F	ND	M	N			PS		N		47
Gambelia wislizenii	W	CT	D	Y	-113.98	-108.65	PL PS		Y	A	48
Gastrophryne olivacea	J	CT	D	Y	-111.2715	-105.1958	PS		Y		49
Gryllus complex	J	CT	D M	Y	-113.2537	-106.8939			N	A S	50
Hypsiglena torquata	C	CT	D	Y	-111.0230	-109.3432	M	Y	Y		7,9,51,52
Kinosternon flavescens	SM	CT	D	Y	-111.5420	-108.5336	M PL		Y	A	53
Lampropeltis getula	C	CT	D	Y	-109.8899	-109.0344	PL		Y	E	7,54,55
Lampropeltis pyromelana complex	C	CT					PL	Y		E	56
Lampropeltis splendida, L. californiae	C	CT					PS	Y		E	56
Lophocereus schottii	SS	CT	D								57

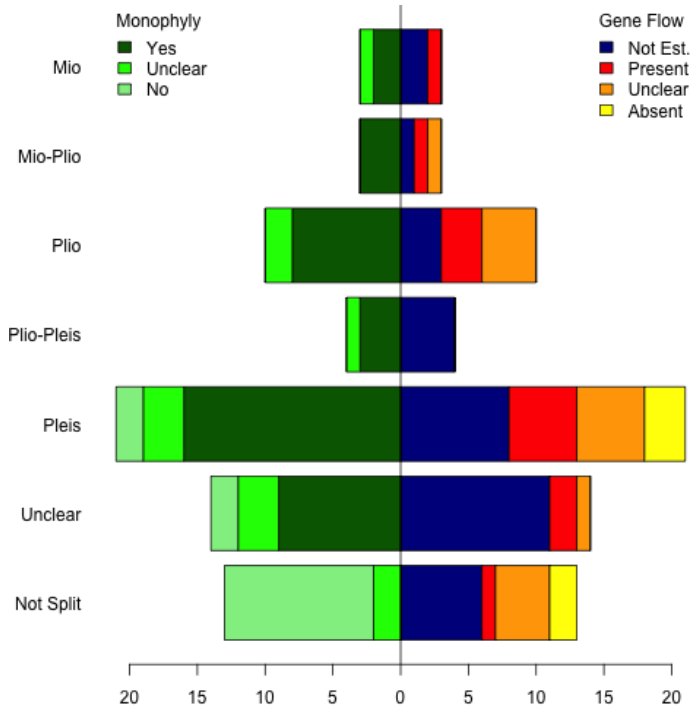
Masticophis flagellum	C	CT	D	Y	-110.2167	-109.1358	M PL	Y	Y	E	7,9,58,59
Melampodium leucanthum	SS	CT	D M	Y	-110.253	-104.857	PS	Y	Y	A P	60
Melozone fusca	F	ND	D	Y	-109.0490	-103.0644	PS	N	Y	A E	10,11,61,62
Moneilema appressum	W	CT	D M				PS				63
Myotis spp.	F	ND	D M	N					N		64
Notiosorex crawfordi	W	ND	D M	Y	-111.04	-109.21			Y		65
Odocoileus hemionus complex	W	ND	D M						N		66
Onychomys complex	W	ND	D	Y	-118.33	-107.15			Y	A	67
Peromyscus eremicus	W	ND	D M	Y	-108.7410	-105.27	PS		Y	A	19,68,69
Phrynosoma cornutum	W	CT	D	Y	-109.67	-104.21	PL PS			A	70
Phrynosoma cornutum complex	W	CT	D	Y					Y		71
Phrynosoma hernandesi complex	W	CT	D M						Y		71
Phrynosoma modestum complex	W	CT	D	Y					Y		71
Phrynosoma orbiculare complex	W	CT	D M						Y		71
Pituophis catenifer	C	CT	D M	Y	-109.4382	-108.0766	PL		Y		7,9,72,73
Pogonomyrmex barbatus, P. rugosus	W	CT	D M	Y	-109.2333	-108.3666		Y	Y	A H	74
Polioptila melanura	F	ND	D	N				Y	N		10,11,75
Pseudotsuga menziesii	SS	CT	M	N			PS		N		76,77
Pseudouroctonus savvasi complex	W	CT	D M	Y	-106.423	-104.785	M			A	78
Rhinocheilus lecontei	C	CT	D	Y	-106.9927	-100.5309	PL		Y	E	7,8,9,70
Salvadora hexalepis	C	CT	D				PS		Y	E	7,9
Sceloporus magister	W	CT	D	Y	-109.0731	-106.8828	PL	Y	Y		79
Sciurus aberti	W	ND	M	Y	-109.67	-107.48	PS		Y	A	80
Sitta carolinensis	F	ND	M	N			PS		N		81
Sonora semiannulata	C	CT	D	Y	-110.6524	-101.2193		Y		E	9,82
Spilogale gracilis	W	ND	M	Y	-109.3515	-105.9272	PS		Y	A	83
Thamnophis marcianus	C	CT	D		-107.7663	-104.6466	PS		Y	E	7,9
Thomomys bottae complex	W	ND	D M				PS	Y	N		84
Toxostoma curvirostre	F	ND	D	Y	-108.86	-104.75	PS		Y	A E	11,61,85,86,87
Toxostoma lecontei	F	ND	D	N					N		10,88,89,90,91
Trimorphodon biscutatus	C	CT	D M	N			PS		N		7,9,92,93,94
Urosaurus ornatus	W	CT	D M	Y	-109.16	-104.68	PS	N	Y		95
Vaejovis vorhiesi	W	CT	M	Y	-112.1830	-109.8627	M		Y	A	96
Vireo bellii	F	ND	D	Y	-108.795	-104.6851	PS	N	Y	A	97
Xantusia complex	W	CT	D M								98

[1] Ayoub and Riechert 2004. [2] Liebherr 1986. [3] Mantooth et al., 2013. [4] Jaeger et al., 2005. [5] Bryson Jr et al., 2012. [6] Weyandt and Van Den Bussche 2007. [7] Myers et al., 2017b. [8] Dahn et al., 2018. [9] Myers et al., 2019b. [10] Zink 1996. [11] Zink et al., 2001. [12] Hosner et al., 2015. [13] Teutimez 2012. [14] Smith et al., 2011. [15] Provost et al., 2018. [16] Manthey et al., 2011. [17] Andersen and Light 2012. [18] Riddle 1995. [19] Riddle et al., 2000a. [20] Hoekstra et al., 2005. [21] Lee et al., 1996. [22] Jezkova et al., 2009. [23] Moore et al., 1991. [24] Manthey et al., 2017. [25] Aguillon et al., 2018. [26] Omland et al., 2000. [27] Omland et al., 2006. [28] Webb et al., 2011. [29] Haring et al., 2012. [30] Johnsen et al., 2017. [31] Kearns et al., 2018. [32] Castoe et al., 2007. [33] Schield et al., 2015. [34] Schield et al., 2017. [35] Anderson and Greenbaum 2012. [36] Schield et al., 2018. [37] Ashton and de Queiroz 2001. [38] Davis et al., 2016. [39] Pook et al., 2000. [40] Douglas and Schuett 2002. [41] Castellanos-Morales et al., 2018. [42] Wilson and Pitts 2008. [43] Wilson and Pitts 2010. [44] Ball and Avise 1992. [45] Pulgarín-Restrepo 2011. [46] Pulgarín-Restrepo and Burg 2012. [47] Klicka et al., 2011. [48] Orange et al., 1999. [49] Streicher et al., 2012. [50] Gray et al., 2016.

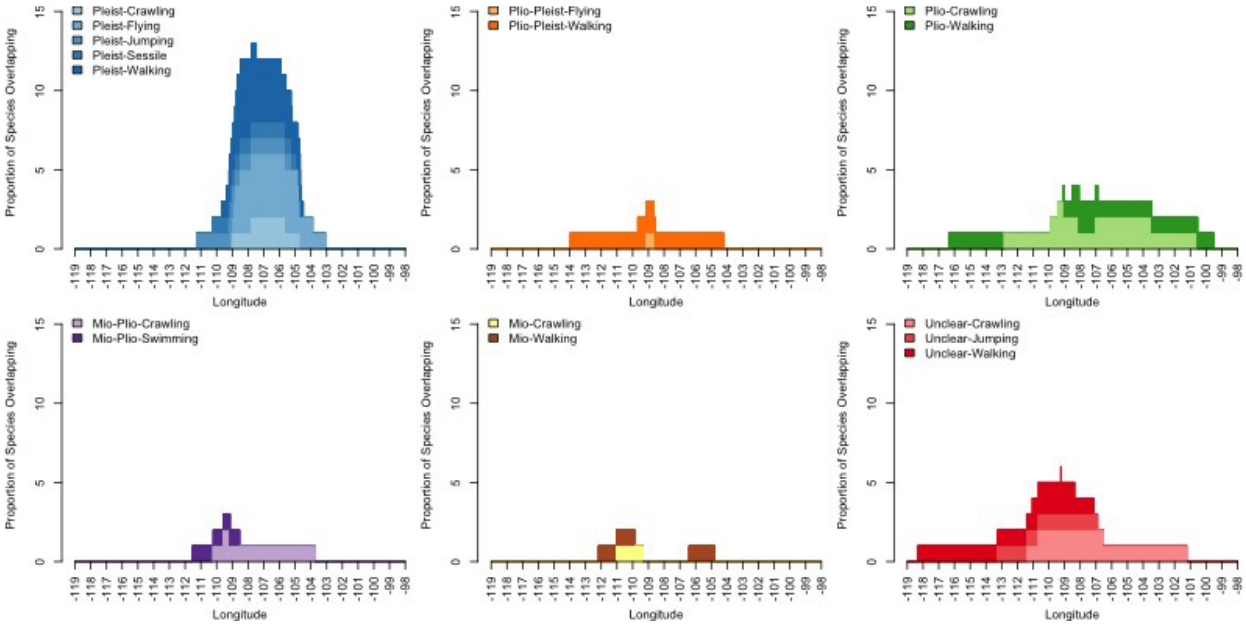
[51] Mulcahy 2008. [52] Mulcahy and Macey 2009. [53] Serb et al., 2001. [54] Pyron and Burbrink 2009. [55] Myers et al., 2019a. [56] Burbrink and Gehara 2018. [57] Nason et al., 2002. [58] Myers et al., 2017a. [59] O'Connell et al., 2017. [60] Rebernig et al., 2010. [61] Zink 2014. [62] Zink and Klicka 2000. [63] Smith and Farrell 2005. [64] Rodriguez and Ammerman 2004. [65] McAliley et al., 2007. [66] Latch et al., 2009. [67] Riddle and Honeycutt 1990. [68] Walpole et al., 1997. [69] Riddle et al., 2000b. [70] Rosenthal and Forstner 2004. [71] Leaché and McGuire 2006. [72] Bryson Jr et al., 2011a. [73] Bryson Jr et al., 2011b. [74] Mott et al., 2015. [75] Smith et al., 2018. [76] Gugger et al., 2010. [77] Gugger et al., 2011. [78] Bryson Jr et al., 2013b. [79] Leaché and Mulcahy 2007. [80] Lamb et al., 1997. [81] Spellman and Klicka 2007. [82] Cox et al., 2018. [83] Ferguson et al., 2017. [84] Belfiore et al., 2008. [85] Zink and Blackwell-Rago 2000. [86] Rojas-Soto 2003. [87] Rojas-Soto et al., 2007. [88] Zink et al., 1999. [89] Zink et al., 1997. [90] Lovette et al., 2012. [91] Vazquez-Miranda et al., 2017. [92] LaDuc and Johnson 2003. [93] Devitt 2006. [94] Devitt et al., 2008. [95] Haenel 2007. [96] Bryson Jr et al., 2013a. [97] Klicka et al., 2016. [98] Sinclair et al., 2004.

Supplementary Table 2.4: Model results for all 33 statistics. See also Table 2.1."Gens" = generations simulations run for. "Prec" = model precision. "Acc" = model accuracy. Accuracies are calculated for phylogeographic structure alone (P), IBD alone (I), and ages alone (A) when applicable.

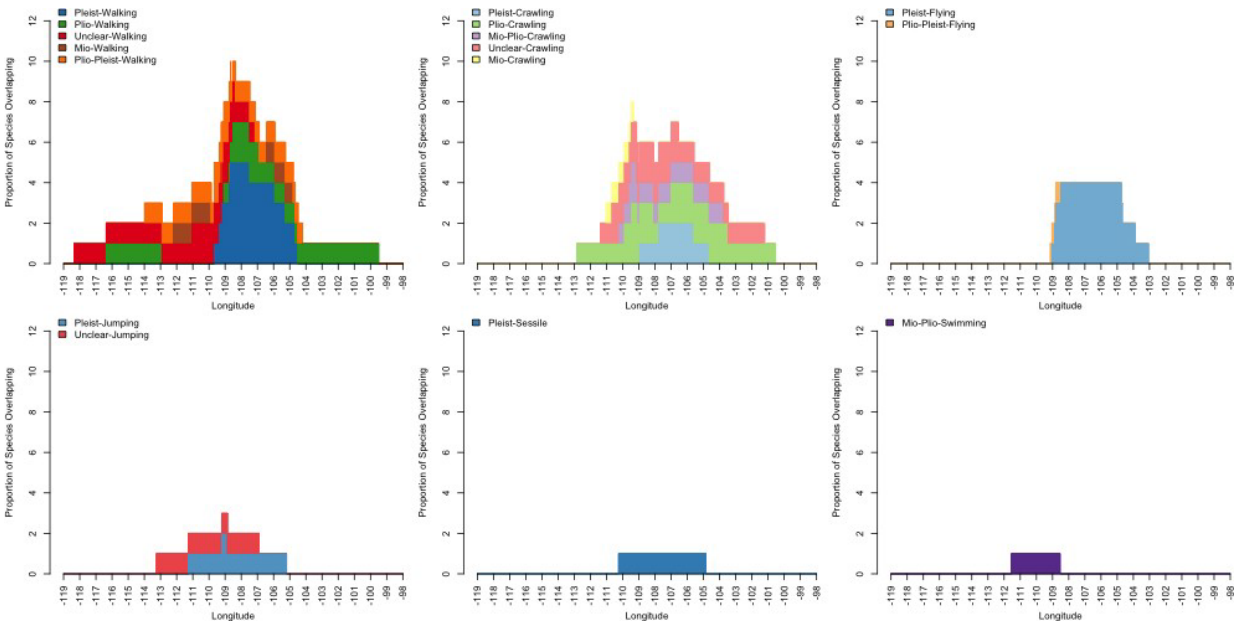
Gens	Dataset	Prec	Recall	F-score	Acc (P)	Acc (I)	Acc (A)
6,000	Training	0.75	0.75	0.75	0.75	1.00	n/a
6,000	Validation	0.24	0.24	0.24	0.30	0.84	n/a
6,000	Test	0.24	0.24	0.24	0.28	0.81	n/a
21,000	Training	0.87	0.87	0.87	0.88	0.98	n/a
21,000	Validation	0.29	0.29	0.29	0.35	0.85	n/a
21,000	Test	0.29	0.29	0.29	0.36	0.84	n/a
120,000	Training	0.92	0.92	0.92	0.93	0.99	n/a
120,000	Validation	0.41	0.41	0.41	0.46	0.89	n/a
120,000	Test	0.41	0.41	0.41	0.47	0.87	n/a
1,000,000	Training	0.93	0.93	0.93	0.94	0.98	n/a
1,000,000	Validation	0.54	0.53	0.53	0.57	0.89	n/a
1,000,000	Test	0.51	0.51	0.50	0.64	0.81	n/a
All	Training	0.54	0.54	0.53	0.64	0.94	0.85
All	Validation	0.22	0.23	0.22	0.38	0.84	0.68
All	Test	0.20	0.21	0.20	0.35	0.83	0.66



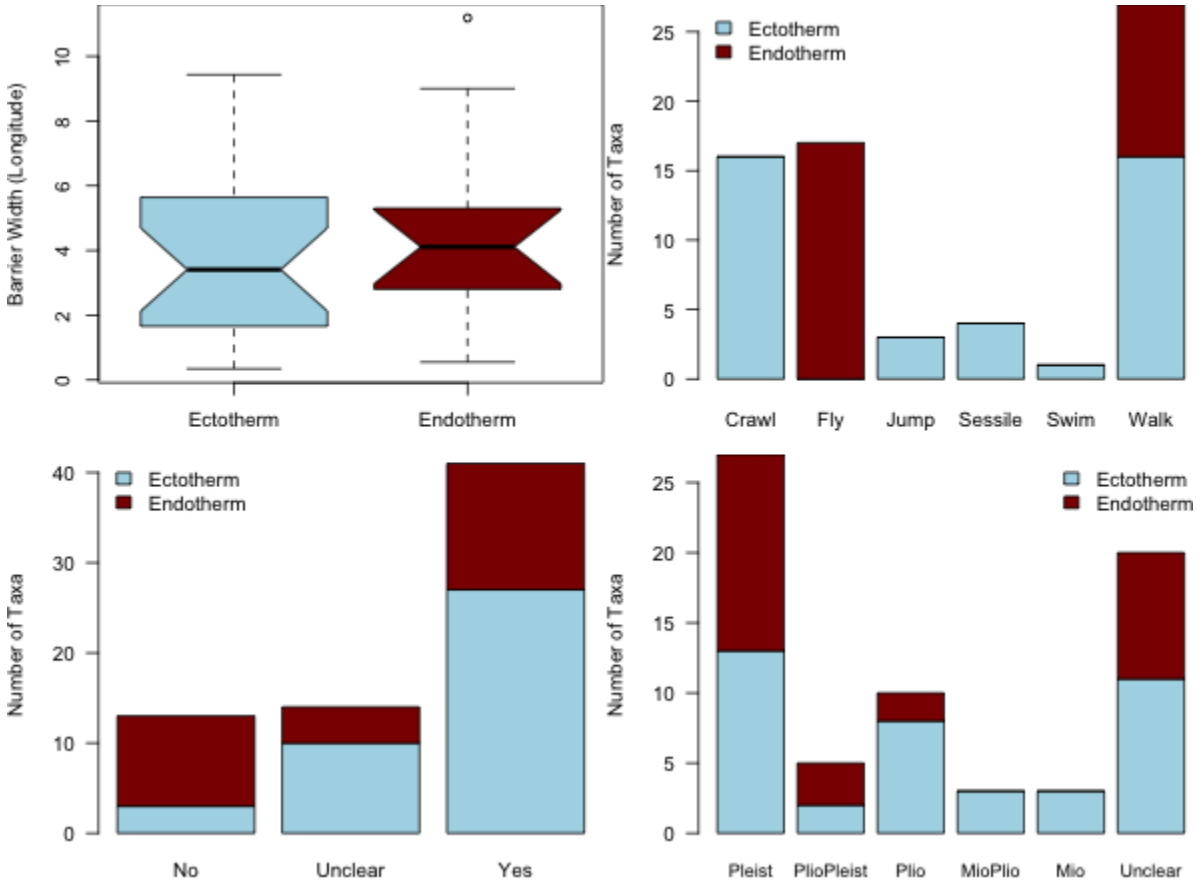
Supplementary Figure 2.1: Most of the studied taxa across the Cochise Filter Barrier split during the Pleistocene and did not have gene flow assessed. Monophyly and gene flow assessment varies across taxa and across time. Y-axis shows the timing of the split across the Cochise Filter Barrier (if present). X-axis shows the number of taxa that fall into each category. Left side of the figure shows whether monophyly across the CFB in the taxa is present (dark green), unclear (bright green), or absent (pale green). Right side of the figure shows gene flow. Colors indicate if gene flow is not estimated (dark blue), present (red), unclear (orange), or absent (yellow).



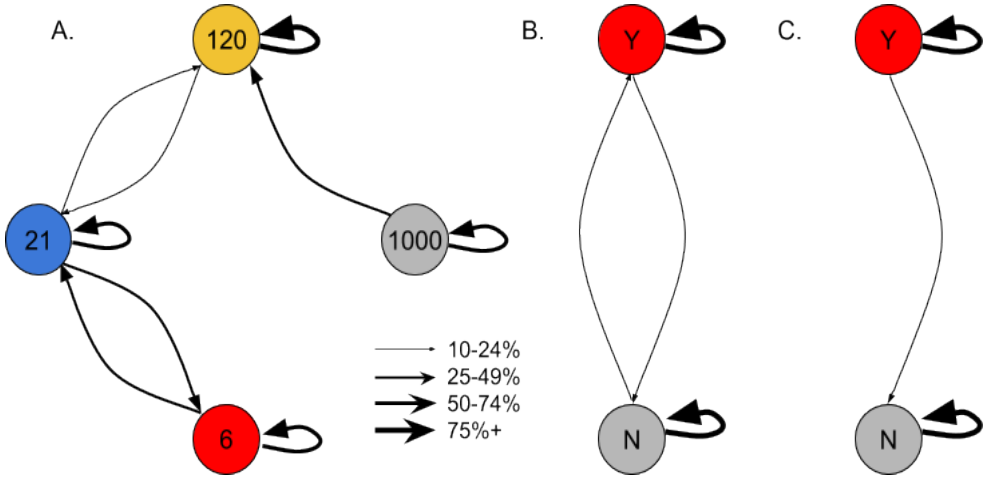
Supplementary Figure 2.2: Taxa that diverge in the Pliocene show a wider CFB than taxa that diverge in other time frames. Colors, hues, and shades as in Figure 2.3. Top panels from left to right: Pleistocene, Pliocene, and Plio-Pleistocene. Bottom panels from left to right: Mio-Pliocene, Unknown, and Miocene.



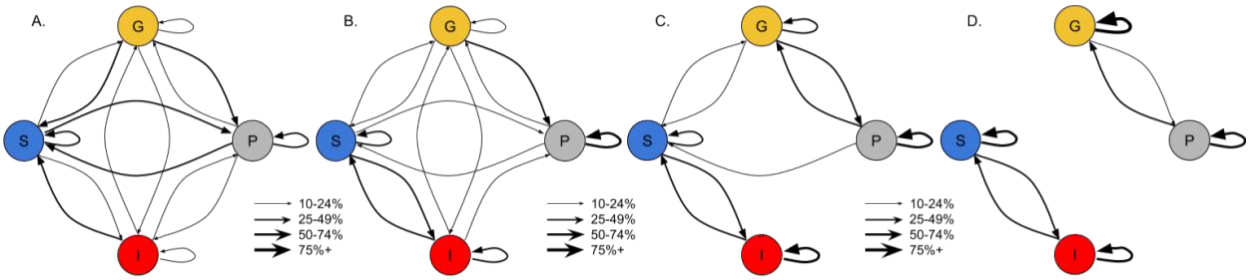
Supplementary Figure 2.3: Taxa that walk show a wider CFB than taxa that crawl or fly. Colors, hues, and shades as in Figure 2.3. Top panels from left to right: crawling, flying, and jumping. Bottom panels from left to right: sessile, walking, and swimming.



Supplementary Figure 2.4. Endothermic species (blue-grey) show more consistent contact zone widths, proportionately less phylogeographic structure, and younger divergence times than ectothermic species (dark red). Top left: boxplot showing the width of the barrier's contact zone (longitude) between ecto- and endo-thermic species. Top right: number of species with different locomotion types that are ecto- or endo-thermic. Bottom left: the number of taxa that show presence, absence, or ambiguous phylogeographic structure (see legend colors) for endo- and ecto-thermic species. Bottom right: divergence epochs for taxa with phylogeographic structure colored by endo- and ecto-thermic species.



Supplementary Figure 2.5: Generations since divergence and presence/absence of IBD are easy to classify. Arrows indicate model assignments. Arrows as in Figure 2.6. A) Confusion between different ages, 6,000 generations ("6") through 1,000,000 generations ("1000"). B) Confusion between IBD present ("Y") and absent ("N") for 6,000-120,000 generations. C) As in B for 1,000,000 generations.



Supplementary Figure 2.6: Phylogeographic structure is easy to classify after a long time since divergence, but not after a short time. Arrows and demographic prefixes ("P", "G", "I", and "S") as in Figure 2.6. A) 6,000 generations. B) 21,000 generations. C) 120,000 generations. D) 1,000,000 generations.

APPENDIX B: SUPPLEMENTARY MATERIALS FOR CHAPTER III

Appendix 3.1: Genetic sequencing and analysis details

Of the 221 individuals sequenced, I extracted 33 of the samples using a Phenol-Chloroform protocol but switched to the High Molecular Weight kit for the remaining samples as I was not getting consistently good extractions. I sequenced the individuals at RAPiD Genomics (Gainesville, FL) with low coverage. All individuals sent on the same plate were sequenced across N lanes, where N is the number of samples divided by 20. I sent five plates which ranged from 20–120 individuals (some plates also contained individuals from other projects).

I mapped to the following genomes: *Corvus brachyrhynchos, Parus major, Sturnus vulgaris, Zonotrichia albicollis*, and *Geospiza fortis*. These were Genbank reference numbers GCF_000691975.1, GCF_001522545.2, GCF_001447265.1, GCF_000385455.1, and GCF_000277835.1, respectively. Before mapping, I created pseudo-chromosomal assemblies of these genomes using Satsuma version 3.1.0 (Grabherr et al. 2010) by aligning to the *Taeniopygia guttata* genome, Genbank reference GCF_000151805.1. I also used FastQ Screen version 0.14.0 (Wingett et al., 2018) to remove contamination by filtering out reads that mapped to the following genomes: *Homo sapiens, E. coli, Enterobacteriophage lambda,* and *Rhodobacter sphaeroides*. I also mapped to PhiX. This allowed us to remove microbial contaminants, human contaminants, and PhiX that was added to the sequencing runs.

I converted cleaned fastq files to BAM using bwa version 0.7.15 and picard version 2.18.7-SNAPSHOT from the GATK pipeline (Li and Durbin, 2009; 2010; McKenna et al., 2010; DePristo et al., 2011; Van der Auwera et al., 2013) I prepared the

BAM files to be used in the ANGSD version 0.929 (Korneliussen et al., 2014) pipeline using samtools (Li et al., 2009; Li, 2011), bamUtil version 1.0.14 (Jun et al., 2015), and GATK (McKenna et al., 2010). This pipeline creates genotype likelihoods instead of calling SNPs. I chose to use ANGSD because it is specifically designed for low-coverage sequences. I originally used the GATK pipeline (DePristo et al., 2011; Van der Auwera et al., 2013), but this was resulting in very reduced numbers of SNPs from the stringent filtering.

Appendix 3.2: Morphological methodology details

To quantify morphological variation in my ten focal species, I measured 367 adult male museum round specimens. Using digital calipers, I measured the lengths of the beak, flight feathers, and tarsus. I excluded females and juveniles. Many older museum skins lack information about age and sex—I assumed that unlabeled birds were adult males unless plumage suggested otherwise. Each specimen was measured three times to estimate repeatability, then the measurements were averaged (Goodenough et al., 2010). I also supplemented this data with pre-existing specimen measurements from specimen tags, which were typically only measured once during specimen preparation. I used those raw measurements to calculate beak surface area and volume and the relative aspect ratio of the wing (Kipp's Index; Kipp, 1959).

I calculated all beak measures assuming that beaks were conical—this may be an underestimate in species of *Toxostoma* which have pronounced curves to their bills. I tested whether calculating these values before or after averaging measurements impacted my results. Both sets of measurements were highly correlated (adjusted R_2 values range

95–99%) and my conclusions were not affected by which set I used, so I chose to use values after averaging. I scaled and centered all raw and calculated measurements, unscaled and without log transforms. I assessed differences within species in morphospace using DABEST (Ho et al., 2019) to visualize differences between populations.

I calculated the relative lengths of all morphological metrics to body size, using tarsus length as a proxy for body size (Rising and Somers, 1989; Senar and Pascual, 1997). I did this by performing a linear model, where I predicted the metric of choice from tarsus length, and then took the residuals to be the corrected relative length. I also log transformed my metrics, both the absolute and relative lengths. These metrics were not used in my subsequent analyses, but they did vary substantially from the uncorrected metrics.

Appendix 3.3: Ecological Niche Modeling

I got occurrence data for the focal species by downloading all eBird data in May 2017 (Sullivan et al., 2009). I then supplemented this data with data from GBIF, iNaturalist, and VertNet (gbif.org, inaturalist.org, vertnet.org). GBIF data was retrieved from the following DOIs on October 9th, 2017: https://doi.org/10.15468/dl.0jvomy, https://doi.org/10.15468/dl.9w3468, https://doi.org/10.15468/dl.87sdjs, https://doi.org/10.15468/dl.a1otjs, https://doi.org/10.15468/dl.ejntps, https://doi.org/10.15468/dl.h8aj9l, https://doi.org/10.15468/dl.lw0qwz, https://doi.org/10.15468/dl.nc3113, https://doi.org/10.15468/dl.riixpl, https://doi.org/10.15468/dl.vn53xq, https://doi.org/10.15468/dl.yze7lh.

Obtaining the occurrence data was done using custom R scripts that made use of the following packages: raster (Hijmans, 2019), MASS (Venables and Ripley, 2002), spocc (Chamberlain, 2017), rgeos (Bivand and Rundel, 2017), dplyr (Wickham et al., 2017), sp (Pebesma and Bivand, 2005; Bivand et al., 2013), and dismo (Hijmans et al., 2017). I removed duplicate localities from these datasets per species. Outliers were detected and removed using a probability density function. After this, I thinned the data using spThin (Aiello-Lammens et al., 2015) to account for spatial autocorrelation in the data. Before thinning, I downloaded a total of 115,285 occurrence points across the ten species. After thinning to one point per 10 km, I ended up with a total of 6,024 points (range 369–929 per species).

Datasets included the 19 WorldClim rasters, soil acidity and soil texture (SoilGrids; Hengl et al., 2017), distance to water (calculated from the Commission for Environmental Cooperation 2009 Lakes and Rivers data), elevation, roughness, relief, and slope (NASA SRTM; Farr et al., 2007), land cover (CEC; Homer et al., 2020), and vegetation type (LandFire; Ryan and Opperman, 2013). Note that the LandFire dataset is only available for the USA. I converted all of the datasets to 0.002083333 latitude and 0.002083333 longitude (7.5 arcseconds) and cropped them to 115–97 °W longitude and 26–37 °N latitude. This was used both for the background training extent and the final projection extent. I did analyses with three versions of this data: 1) a climate-only dataset, which includes the 19 BioClim variables only; 2) a North America dataset, which includes all layers except the LandFire data; and 3) a USA dataset, which includes all of the above.

In particular, I used the linear and linear+quadratic feature classes, as well as regularization values of 0.5, 1, 1.5, 2, 2.5, 3, 3.5, and 4. Models were run for each combination of feature classes and regularization values, and the model with the lowest occurrence point omission rate and highest area under the curve was chosen. I used the entire extent of the layers as background points, partitioned with the block method, and thresholded my models when appropriate at the equal sensitivity-specificity threshold. ENMeval analysis on the best model showed that linear-quadratic models always won out over linear models (Supplementary Table 3.3). The AUC values were overall high: for training data they ranged from 0.87–0.97, while for the test data they ranged from 0.83–0.96. Omission rates varied from 7%–26%.

Appendix 3.4: Generalized Dissimilarity Matrix model inputs and details

Abundance data for IBA analyses

From Breeding Bird Survey Data, I extracted 27,154 data points for my 10 focal species (range 622–6,232 per species) across the years 1967–2018. This was a total of 687 routes, with a range of 93–850 data points per year. Abundances vary widely across species (Supplementary Figure 3.5). *Toxostoma crissale* was the least abundant (maximum abundance 3–10 individuals per raster cell), while *Amphispiza bilineata* was most abundant (maximum abundance 100–300 individuals per raster cell). Many taxa are predicted to have a sharp drop off in abundance in the region of the Cochise Filter Barrier.

GDM model methods details

In addition to the bivariate models I described in the main text, I also ran univariate models and multivariate models. The bivariate models accounted for structure, here defined as a distance matrix where individuals assigned to different sides of the CFB had a distance of 1, individuals who were assigned to the same side had a distance of 0, and individuals whose assignment was ambiguous (across datasets or due to high levels of admixture) had a distance of 0.5 to all other individuals. These assignments were based off of the K=2 analyses for all taxa. In the species that did not show longitudinal population structure, I assigned them to sides of the CFB based on where they fell relative to 108 °W longitude. This structure distance matrix was used as a random effect in all bivariate and multivariate models such that I was only testing between the other predictors. The multivariate models additionally had IBD included as a random effect. The univariate models, in contrast, used structure as a predictor (included as IBH). I chose not to do multivariate models with multiple predictor matrices at once (i.e., as static effects not random effects) because the sample sizes in my data precluded me from using models with high complexity.

Univariate models had the formula as follows: genetic/phenotypic distance matrix ~ one of six predictor matrices (geographic distance, abundance resistance, environmental distance, environmental resistance, paleoclimate resistance, or structure distance). Bivariate models had this formula: genetic/phenotypic distance matrix ~ (1|structure distance) + one of the five remaining predictor matrices. Multivariate models instead had this formula: genetic/phenotypic distance matrix ~ (1|structure distance) + (1|geographic distance) + one of the four remaining predictor matrices.

When I examined the univariate model results, the best models explaining variation in the genome was 5/10 IBH, 3/10 IBE, 1/10 IBA, and 1/10 IBD with no ties. Across all of the data, 375 tests were successful in both univariate and bivariate models, and 75.2% of them have the same best model selected. In the chromosomes, IBE explains 36% of the observed variation, IBA explains 32%, IBH explains 14%, IBD explains 13%, and the remaining 5% is explained by a mixture of models. The best model selected for each of the chromosomes only matched that of the genome 33.7% of the time. In the 333 chromosome datasets, IBE was most important in 30.0%, IBH most important in 29.1%, IBA most important in 25.2%, IBD most important in 8.7%, and a mixture of models were most important in 6.9%. When looking at the 37 phenotypic model results, these numbers were 16%, 8.1%, 29.7%, 21.6%, and 8.1%, respectively. Percent deviance was again low, with only 93/380 datasets having more than 10% explained (range 0.00-74.71%, mean±standard deviation 9.27±12.68%).

When examining correspondence between the summary statistics and which model best explained the data, neither F_{ST} nor D_{XY} were significant ($p>0.527$). While the overall model for recombination rate was significant ($p=0.046$), Tukey's honestly significant difference tests showed that none of the individual comparisons were significant ($p>0.145$). Datasets with mixed support among models once again had more missing data than all other models ($p<0.0002$). For chromosome lengths, the overall model was significant ($p=0.048$) showing that shorter chromosomes were more likely to have IBD over IBH be chosen as the best model, but that comparison was not significant ($p=0.077$).

When I examined the multivariate model results, the best models explaining variation in the genome was 4/10 IBH, 4/10 IBE, and 2/10 IBA with no ties. Chromosomes matched the models 33.9% of the time. Across all of the data, 343 tests were successful in both univariate and multivariate models, and 86.5% of them have the same best model selected (if the 38 bivariate models with IBD are excluded, this percentage is 97.3%). In the chromosomes, IBE explains 42.9% of the observed variation, IBA explains 33.3%, IBH explains 19.2%, and the remaining 7.5% is explained by a mixture of models. None of the phenotypic models converged. The percent deviance tended to be lower than univariate or bivariate models, with only 74/343 datasets having more than 10% explained (range 0.00–54.99%, mean±standard deviation 7.86±11.23%).

Neither F_{ST} nor the chromosome length explained the best model selected ($p>0.315$). Missing data is once again significant for mixed models compared to the rest ($p<0.0025$), and for IBH models compared to IBA and IBE when *P. nitens* was not excluded (included $p<0.0017$, excluded $p>0.65$). IBE models and IBA models are different in recombination rate ($p=0.040$) and D_{XY} ($p=0.068$).

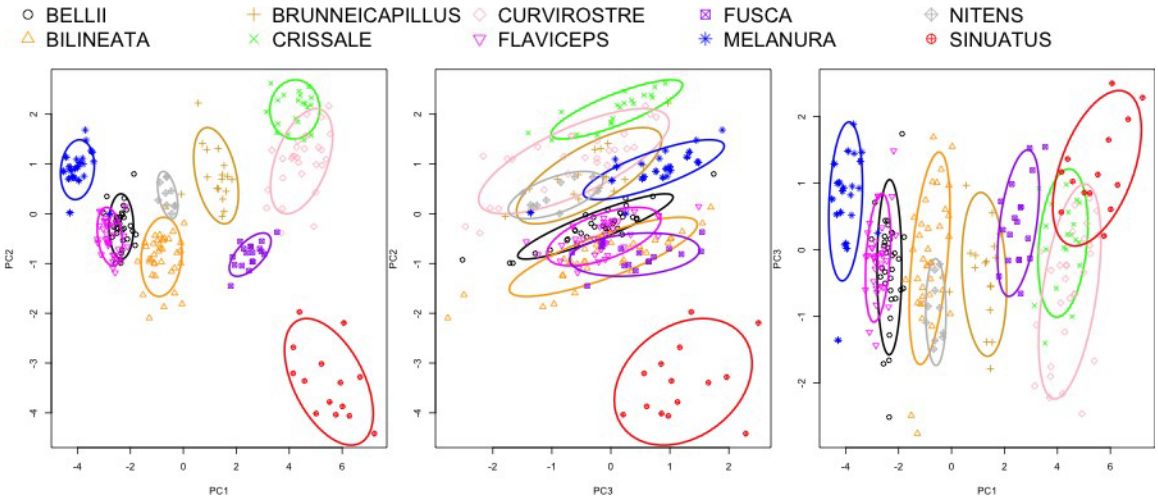
Appendix 3.5: Supplementary Figures and Tables for Chapter III.

Supplementary Table 3.1: Importance of principal components for the morphological analysis.

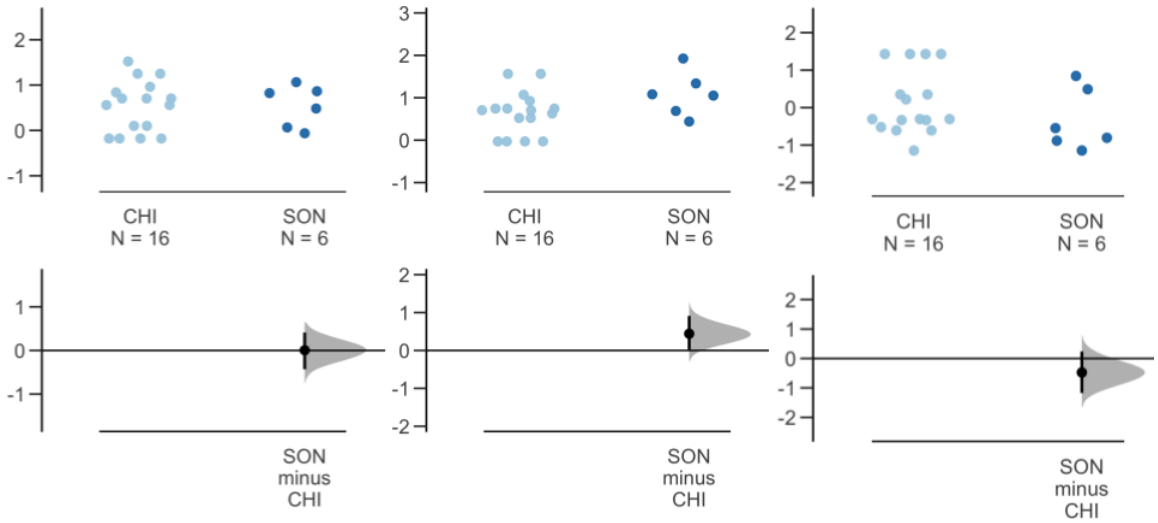
PC	Standard Deviation	Proportion of Variance	Cumulative Proportion
1	3.23	0.74	0.74
2	1.29	0.12	0.86
3	0.90	0.06	0.92
4	0.69	0.03	0.96
5	0.55	0.02	0.98
6	0.40	0.01	0.99
7	0.24	4.27×10^{-3}	0.99
8	0.22	3.48×10^{-3}	0.99
9	0.17	2.05×10^{-3}	0.99
10	0.09	5.30×10^{-4}	0.99
11	0.07	3.60×10^{-4}	0.99
12	0.02	3.00×10^{-5}	0.99
13	0.01	1.00×10^{-5}	0.99
14	1.24×10^{-10}	0	1

Supplementary Table 3.2: Loadings of the first three principal components from the raw morphological measurements.

Measurement	PC1	PC2	PC3
Bill Height	0.25	-0.40	0.18
Bill Length	0.25	0.41	-0.19
Bill Width	0.28	-0.30	0.10
Tarsus Length	0.27	0.26	-0.10
Primaries Length	0.29	0.10	-0.18
Secondaries Length	0.29	0.15	-0.08
Tail Length	0.28	0.21	-0.03
Kipp's Index	-0.10	-0.39	-0.85
Beak Base Area	0.24	-0.42	0.26
Beak Volume	0.29	-0.03	0.09
Beak Lateral Surface Area	0.29	0.19	-0.06
Beak Full Surface Area	0.30	-0.07	0.08
Beak Lateral Surface / Volume	-0.26	0.24	0.15
Beak Full Surface / Volume	-0.28	0.05	0.21



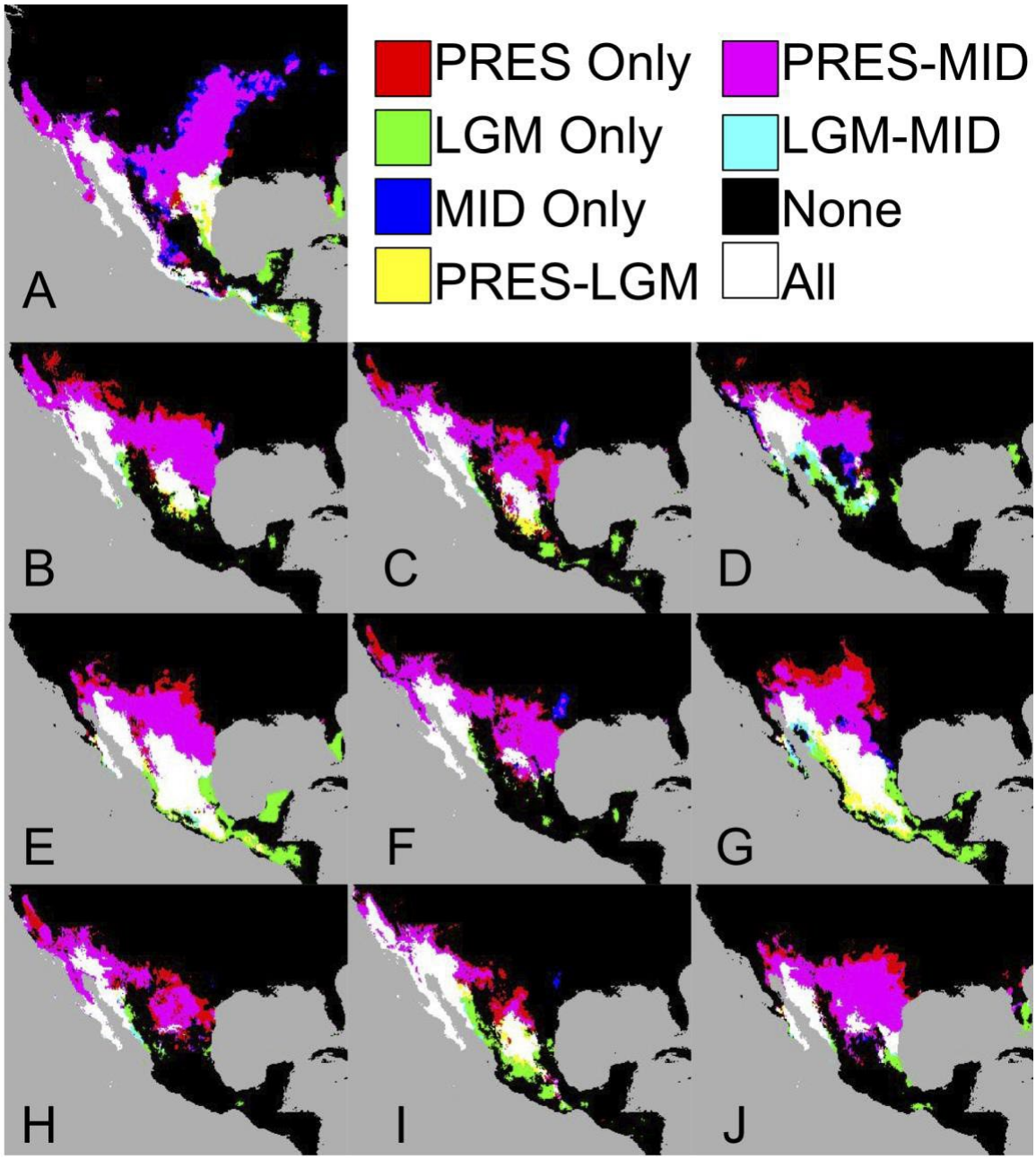
Supplementary Figure 3.2: Principal components analysis plots. Colors and shapes correspond to different species. Lines indicate 50% confidence interval area for the mean of each species. Left: PC1 (x-axis) vs. PC2 (y-axis). Center: PC3 (x-axis) vs. PC2 (y-axis.) Right: PC1 (x-axis) vs. PC3 (y-axis.)



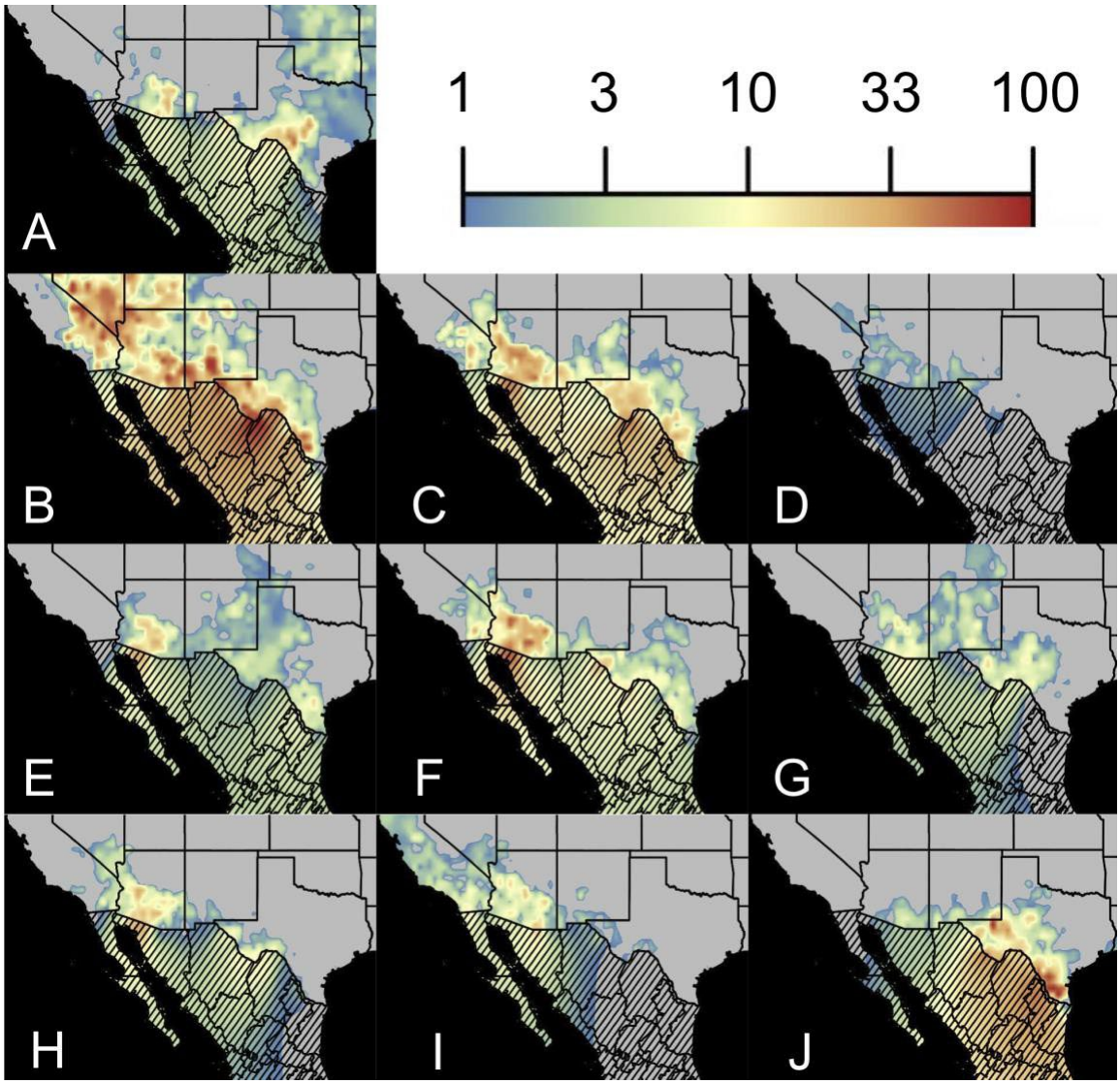
Supplementary Figure 3.3: Top row: raw values for PC1 (left), PC2 (center), PC3 (right) for *A. bilineata* in each desert. Points are jittered on the x-axis for visibility. Bottom row: distribution of differences between Sonoran and Chihuahuan desert individuals from DABEST analysis.

Supplementary Table 3.3: Best models selected to generate the ecological niche models for each species. AUC=area under curve. Train=training dataset. Test=average values across all test datasets. OR=average test 10% omission rate. Reg=regularization parameter. LQ=linear and quadratic.

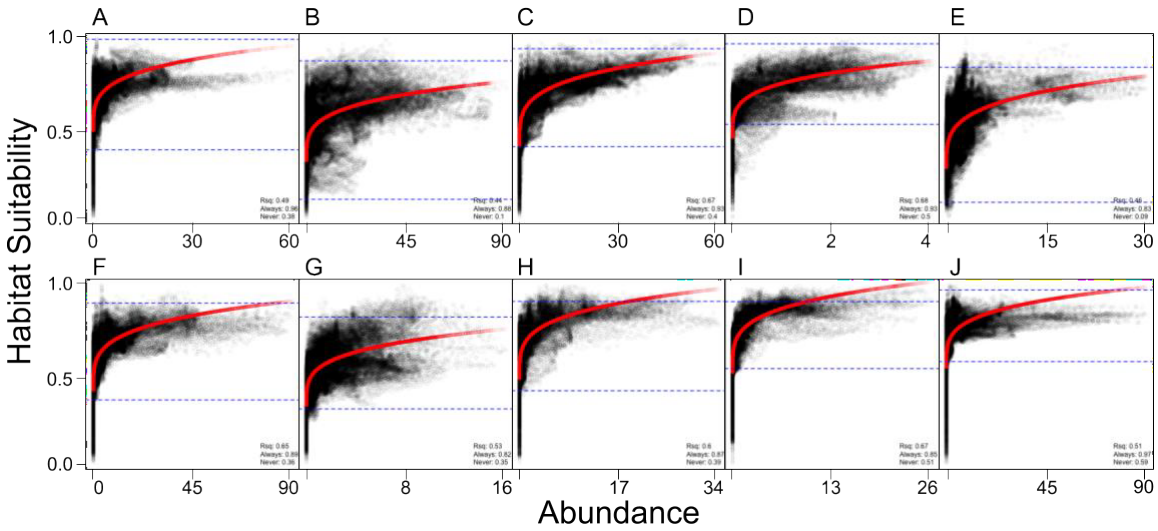
Species	Features	Reg.	Train AUC	Test AUC	OR	Parameters
Toxostoma crissale	LQ	1	0.97	0.96	0.07	18
Amphispiza bilineata	LQ	0.5	0.91	0.90	0.14	25
Toxostoma curvirostre	LQ	2	0.90	0.87	0.13	16
Auriparus flaviceps	LQ	0.5	0.94	0.92	0.20	25
Vireo bellii	LQ	0.5	0.87	0.83	0.14	28
Campylorhynchus brunneicapillus	LQ	0.5	0.93	0.91	0.22	23
Cardinalis sinuatus	LQ	1.5	0.93	0.91	0.23	16
Melozone fusca	LQ	0.5	0.93	0.89	0.26	27
Polioptila melanura	LQ	0.5	0.96	0.95	0.24	23
Phainopepla nitens	LQ	1.5	0.96	0.95	0.23	17



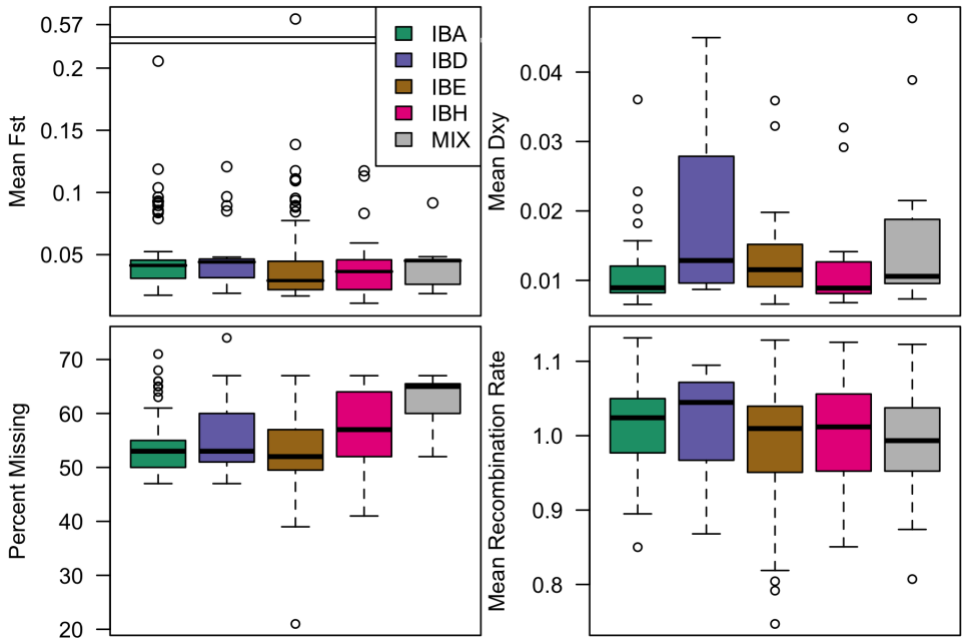
Supplementary Figure 3.4: Visualization of suitable regions across present, mid-Holocene, and Last Glacial Maximum. Colors indicate which regions are suitable at which time periods. A) *V. bellii*, B) *A. bilineata*, C) *C. brunneicapillus*, D) *T. crissale*, E) *T. curvirostre*, F) *A. flaviceps*, G) *M. fusca*, H) *P. melanura*, I) *P. nitens*, J) *C. sinuatus*.



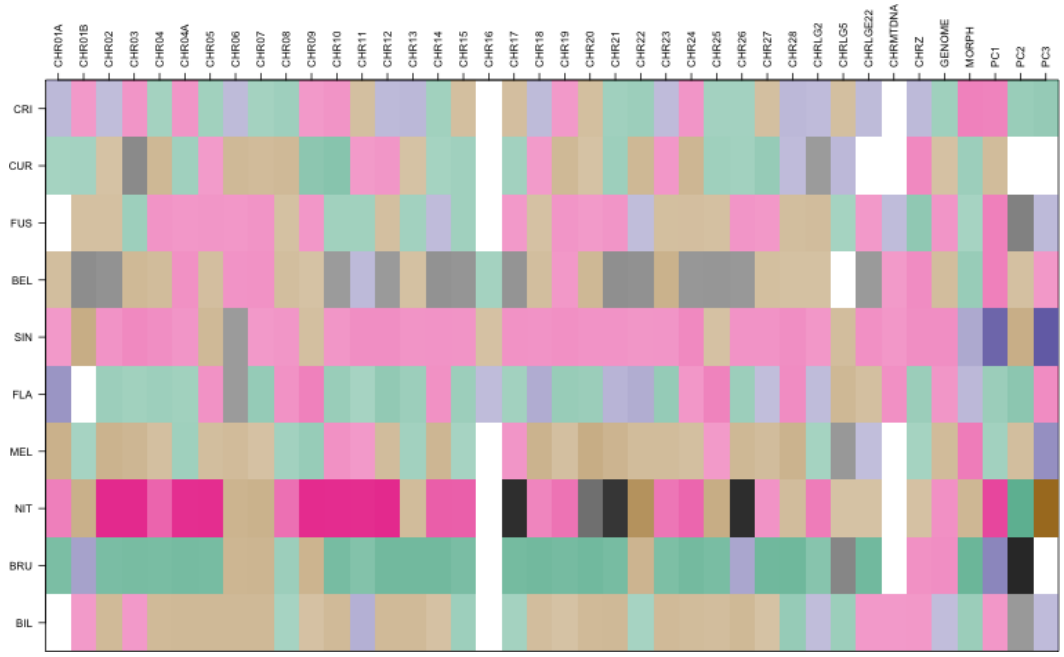
Supplementary Figure 3.5: Estimated abundances across space for two species, averaged over all years. Color is proportional to log abundance. Mexico is shaded out due to the lack of BBS points in that country, but the interpolated projections are included. A) *V. bellii*, B) *A. bilineata*, C) *C. brunneicapillus*, D) *T. crissale*, E) *T. curvirostre*, F) *A. flaviceps*, G) *M. fusca*, H) *P. melanura*, I) *P. nitens*, J) *C. sinuatus*.



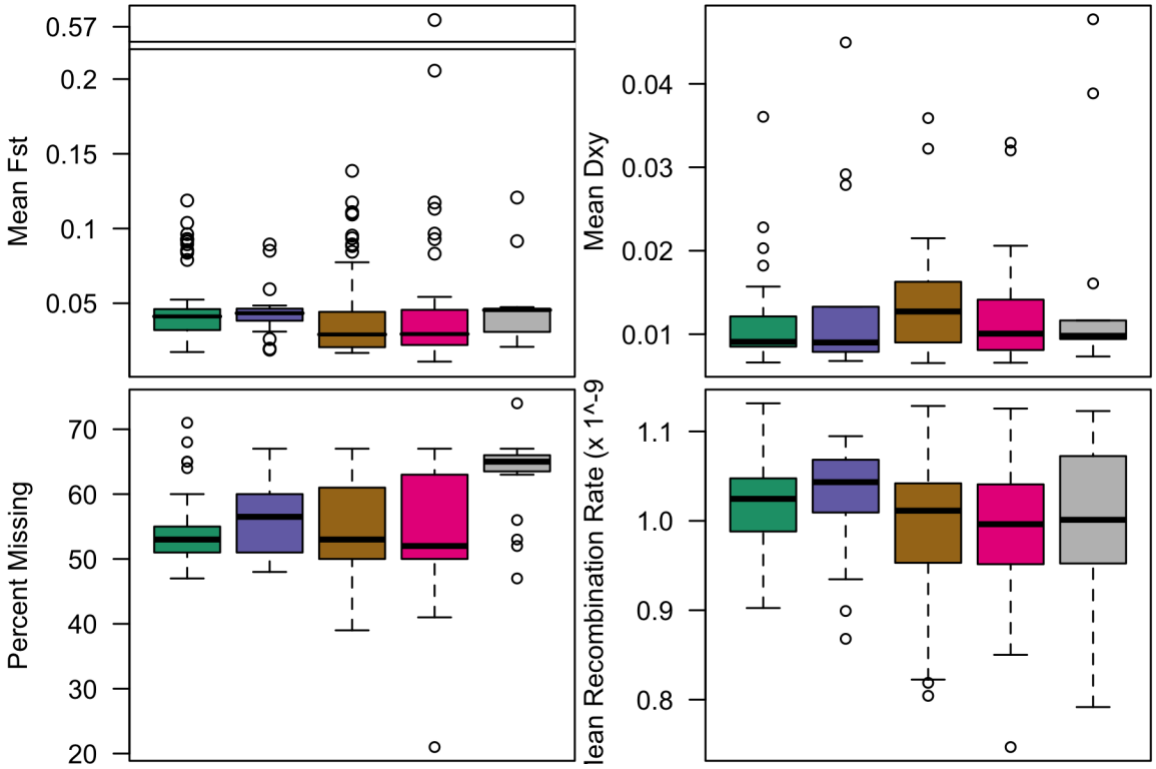
Supplementary Figure 3.6. Interpolated abundance vs. relative habitat suitability for all species (see Figure 3.4). A) *V. bellii*, B) *A. bilineata*, C) *C. brunneicapillus*, D) *T. crissale*, E) *T. curvirostre*, F) *A. flaviceps*, G) *M. fusca*, H) *P. melanura*, I) *P. nitens*, J) *C. sinuatus*.



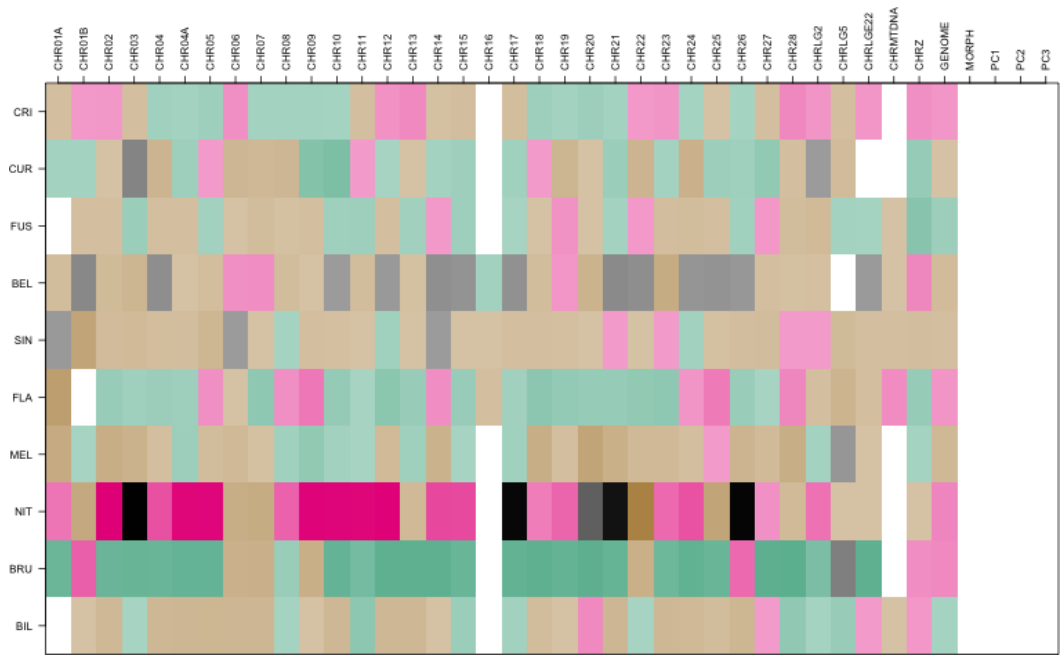
Supplementary Figure 3.7: Variation in summary statistics across chromosomes with different landscape predictors as best model. Upper left: mean F_{ST} across chromosomes. Note that y-axis has the region between 0.22–0.56 removed to better display non-outlier data. Upper right: mean D_{XY} across chromosomes. Lower left: Percent missing data across chromosome. Lower right: mean recombination rate (x 10^{-9}) across chromosomes.



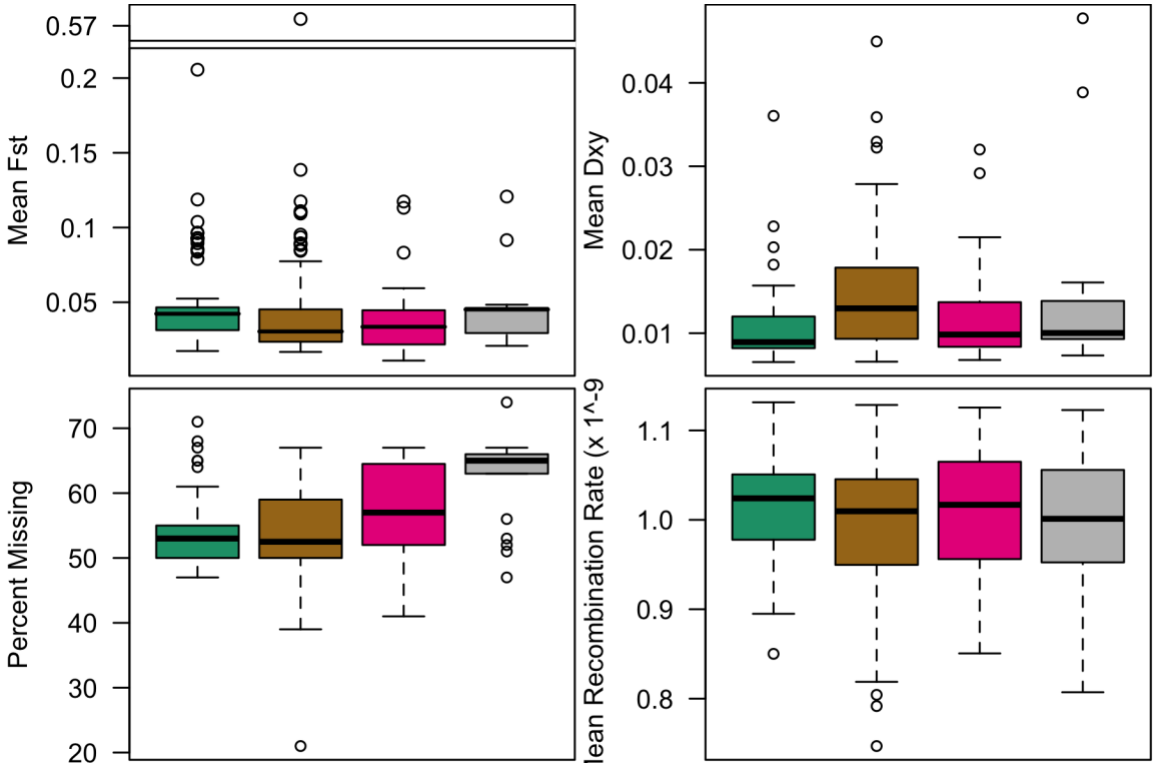
Supplementary Figure 3.8: GDM model summary for univariate models. Colors as in Figure 3.3.



Supplementary Figure 3.9: Variation in summary statistics across chromosomes with different landscape predictors as best model, for univariate models. Colors as in Supplementary Figure 3.7. Upper left: mean F_{ST} across chromosomes. Note that y-axis has the region between 0.22–0.56 removed to better display non-outlier data. Upper right: mean D_{XY} across chromosomes. Lower left: Percent missing data across chromosome. Lower right: mean recombination rate (x 10^{-9}) across chromosomes.



Supplementary Figure 3.10: GDM model summary for multivariate models. Colors as in Figure 3.3.



Supplementary Figure 3.11: Variation in summary statistics across chromosomes with different landscape predictors as best model, for multivariate models. Colors as in Supplementary Figure 3.7. Upper left: mean F_{ST} across chromosomes. Note that y-axis has the region between 0.22–0.56 removed to better display non-outlier data. Upper right: mean D_{XY} across chromosomes. Lower left: Percent missing data across chromosome. Lower right: mean recombination rate (x 10^{-9}) across chromosomes.

APPENDIX C: SUPPLEMENTARY MATERIALS FOR CHAPTER IV

Genetic sampling details

33 of my genetic samples were sequenced with a standard Phenol-Chloroform protocol. However, I did not have success getting good results out, so I switched to the Qiagen kit as described in the main text.

Generating contiguous islands and sweep

I calculated whether islands and sweeps were contiguous with each other in two ways. The first was as described in the text, where islands and sweeps had to be on consecutive windows (i.e., consecutive regions of 100,000 bp that were 10,000 bp apart) to be considered contiguous. The second was a less conservative measurement where islands had to be within one window's length of each other (i.e., less than 10 windows from each other) to be considered consecutive. When I count contiguous windows with this method, I find 16 (rather than 17) island regions and 324 (rather than 490) sweep regions. I also identify additional overlaps between taxa bringing out total to four on chromosome 1 (*P. nitens. P. melanura, C. sinuatus, A. flaviceps, T. curvirostre*), one on chromosome 10 (*V. bellii, T. crissale*), one on chromosome 22 (*V. bellii, T. crissale*), one on chromosome 23 that is associated with a centromere (*V. bellii, T. curvirostre*), three on chromosome 4A (*V. bellii, T. curvirostre, T. crissale*), and 13 on the Z chromosome (*V. bellii, T. curvirostre, T. crissale, A. bilineata*).

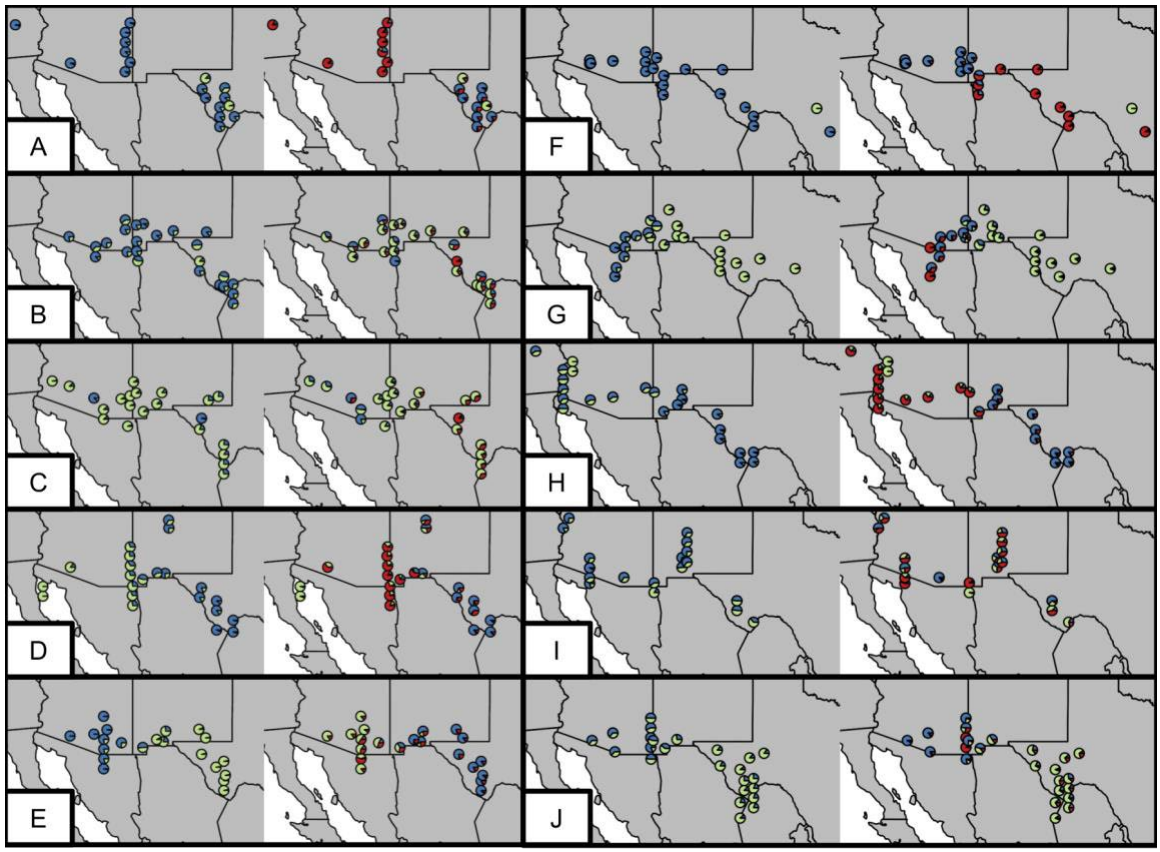
Appendix 4.1: Supplementary Figures and Tables for Chapter IV.

Supplementary Table 4.1: Locations of sweeps by chromosome and by species. Chromosomes omitted have no sweeps. "Chr" stands for chromosome. Species names are shortened: *"bil" = A. bilineata, "fla" = A. flaviceps, "bru" = C. brunneicapillus, "sin" = C. sinuatus, "fus" = M. fusca, "mel" = P. melanura, "nit" = P. nitens, "cri" = T. crissale, "cur" = T. curvirostre, "bel" = V. bellii.*

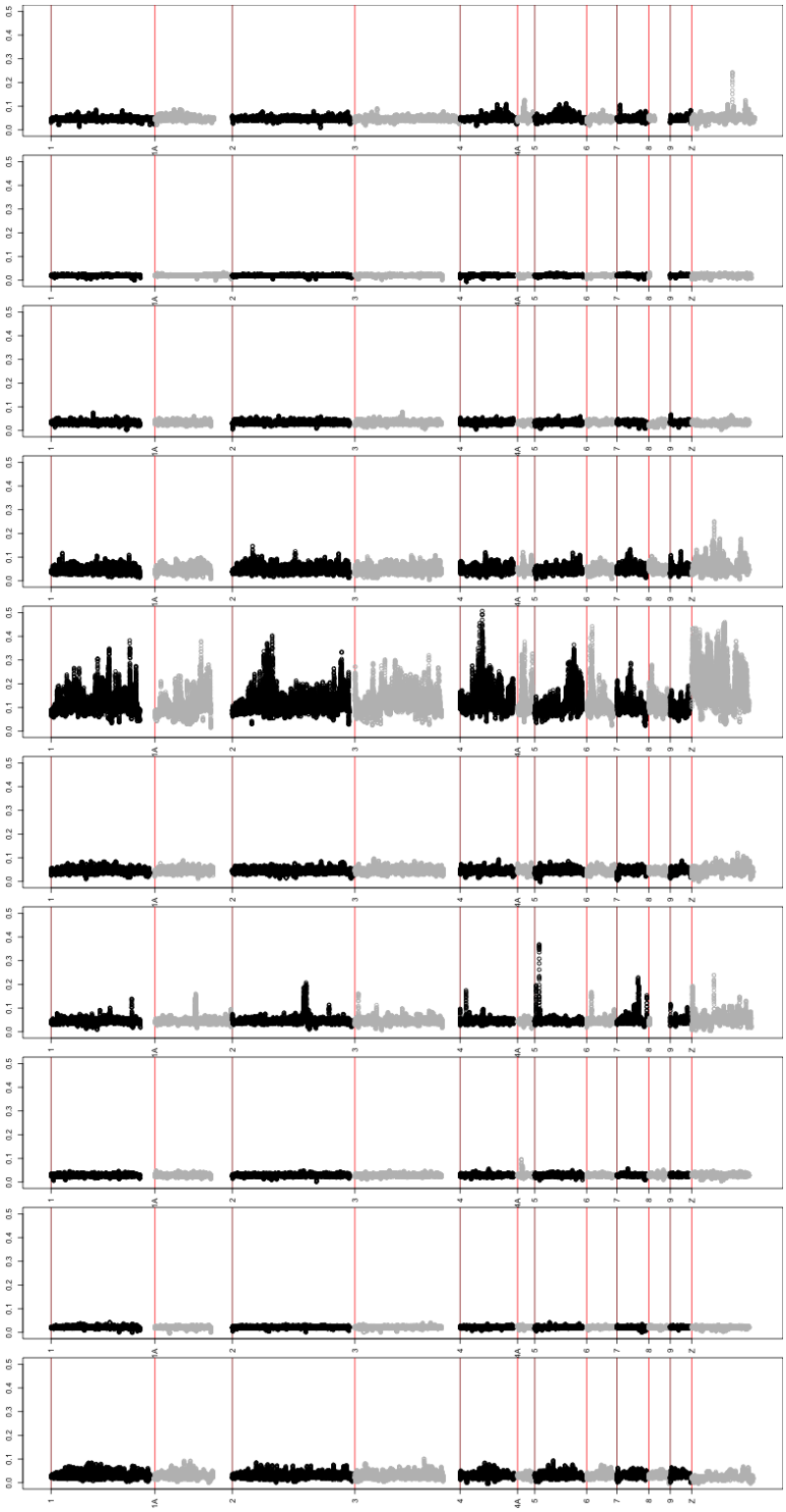
Chr	*bil*	*fla*	*bru*	*sin*	*fus*	*mel*	*nit*	*cri*	*cur*	*bel*
1	15	36	4	37	9	4	64	0	146	147
1A	40	0	12	0	0	0	0	0	14	63
2	0	0	0	0	0	0	0	3	0	66
4	0	0	3	0	0	0	0	0	100	0
4A	0	0	2	0	0	0	0	17	95	366
5	0	0	0	0	0	0	0	20	288	0
10	5	0	0	0	0	0	0	34	0	228
12	38	0	0	0	0	0	0	0	0	12
13	18	0	0	0	0	0	0	0	0	0
15	0	0	2	0	0	0	0	0	0	36
17	0	0	3	0	0	0	0	0	0	0
18	10	0	5	0	0	0	0	0	0	96
19	0	0	7	0	0	0	0	1	0	0
20	12	0	32	0	0	0	0	0	0	0
22	0	0	1	0	0	0	0	10	1	12
23	2	0	0	0	0	0	0	0	14	12
24	20	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	8	0	0
26	0	0	0	0	0	0	0	19	0	0
27	1	0	2	0	0	0	0	0	0	0
Z	84	0	0	0	0	0	0	1113	0	885

Supplementary Table 4.2: Locations of islands by chromosome and by species. Chromosomes and species omitted have no sweeps. Abbreviations as in Supplementary Table 4.1.

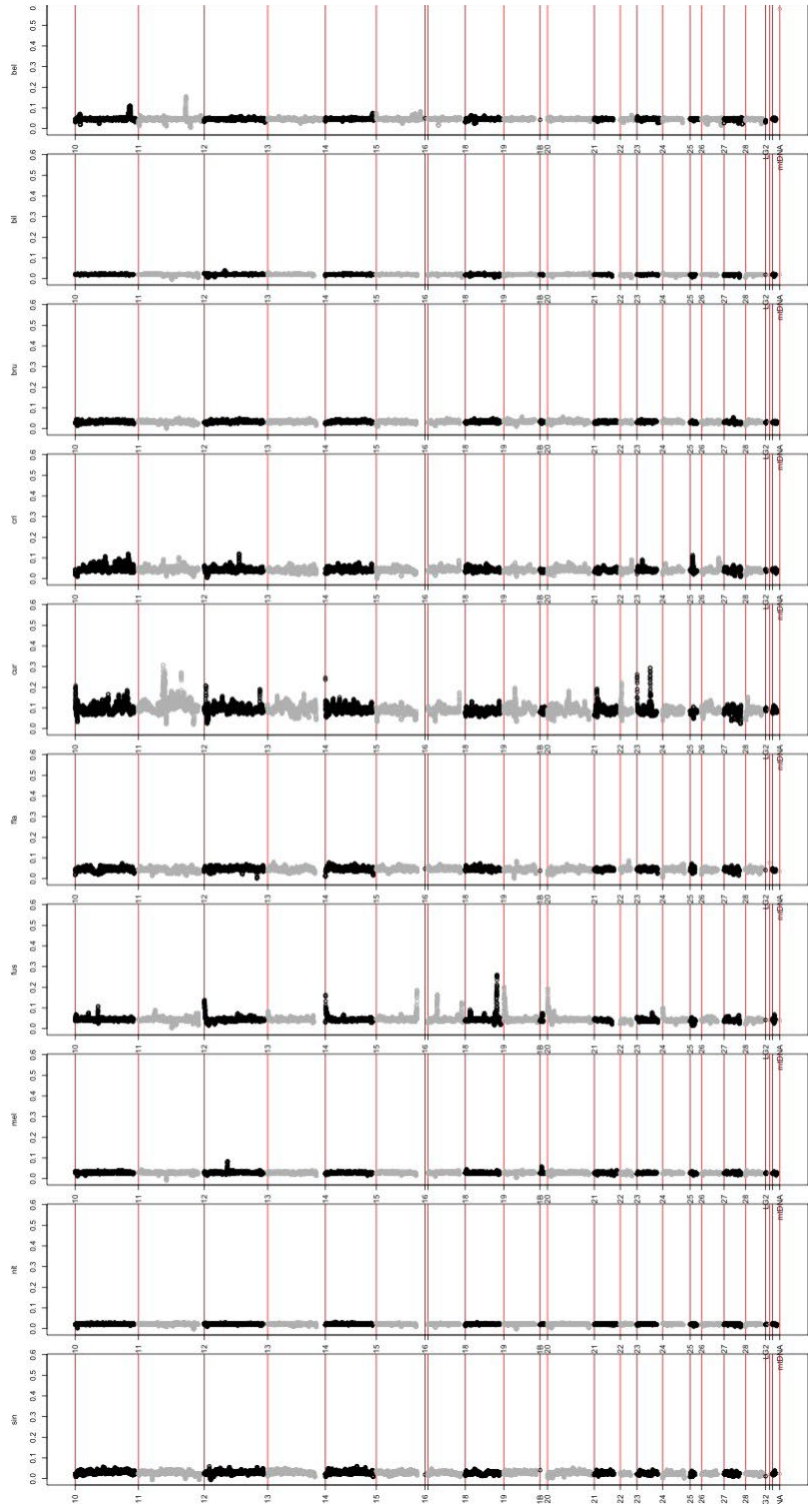
Chr.	*bru*	*sin*	*mel*	*nit*	*cri*	*cur*	*bel*
1	0	64	2	9	0	0	0
4	5	0	0	0	0	1	0
4A	0	0	0	0	1	0	0
Z	0	0	0	0	0	0	3



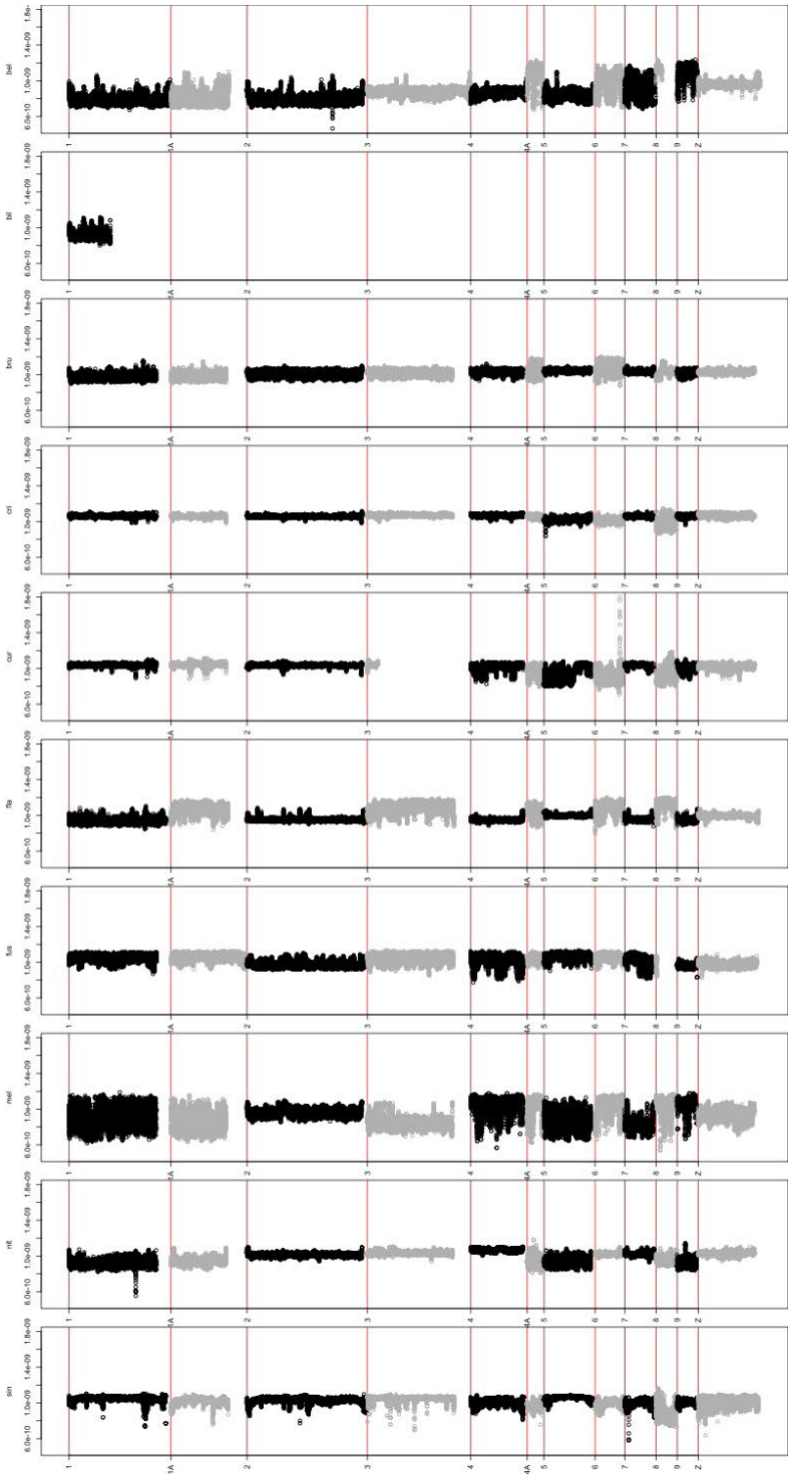
Supplementary Figure 4.1: Population assignment and admixture probabilities for all species, averaging over all chromosomes. Pie chart shows admixture probabilities for each cluster (blue, green, and red). Panels labeled with letters contain K=2 (left) and K=3 for the following species: A) *V. bellii*, B) *A. bilineata*, C) *C. brunneicapillus*, D) *T. crissale*, E) *T. curvirostre*, F) *A. flaviceps*, G) *M. fusca*, H) *P. melanura*, I) *P. nitens*, J) *C. sinuatus*. Pie charts are jittered latitudinally to show all individuals at a given longitude. Columns indicate species while rows indicate analysis methods used.



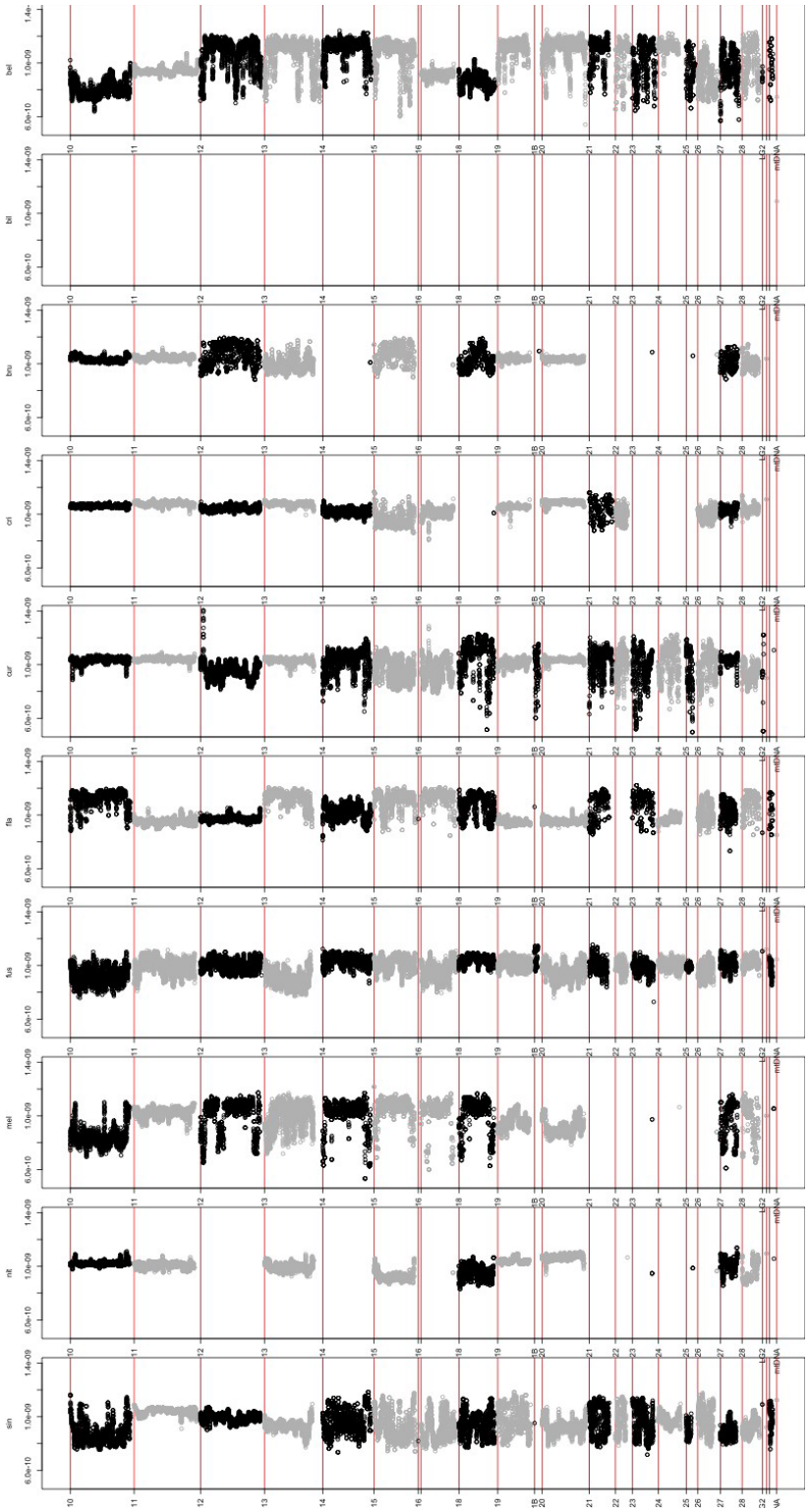
Supplementary Figure 4.2: Mean F_{ST} across the macro-chromosomes for all species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



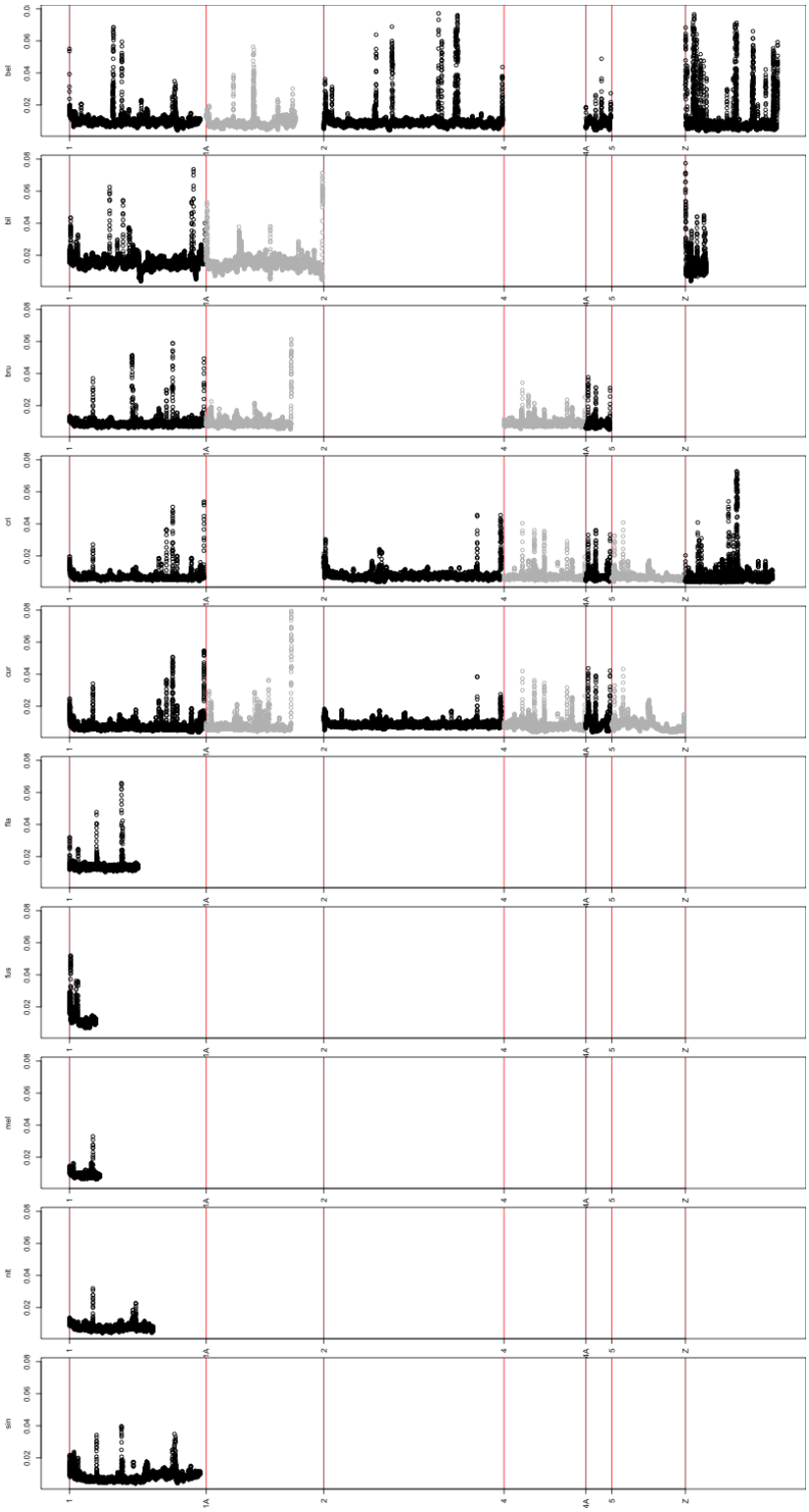
Supplementary Figure 4.3: Mean FST across the micro-chromosomes for all species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



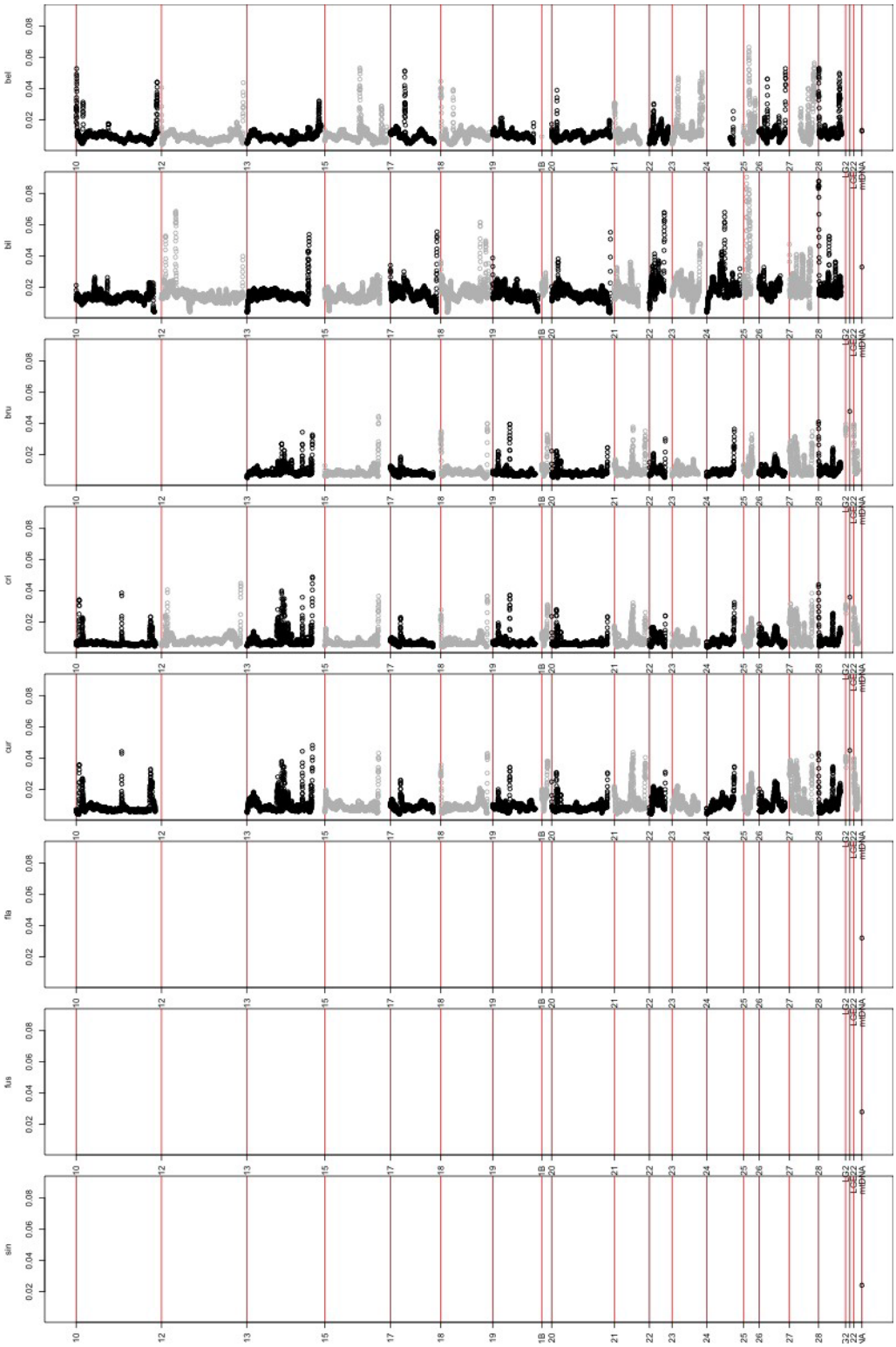
Supplementary Figure 4.4: Mean recombination rate across the macro-chromosomes for all species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



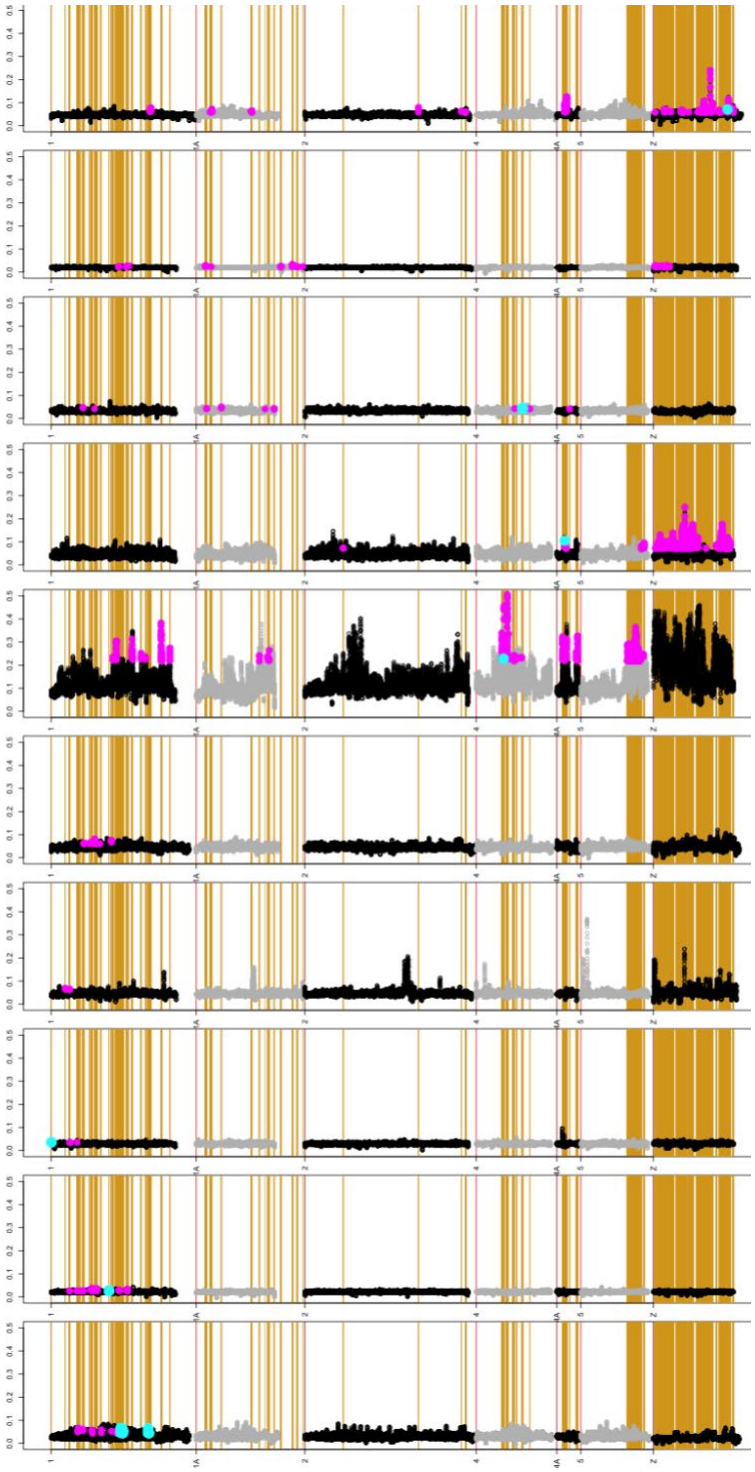
Supplementary Figure 4.5: Mean recombination rate across the micro-chromosomes for all species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



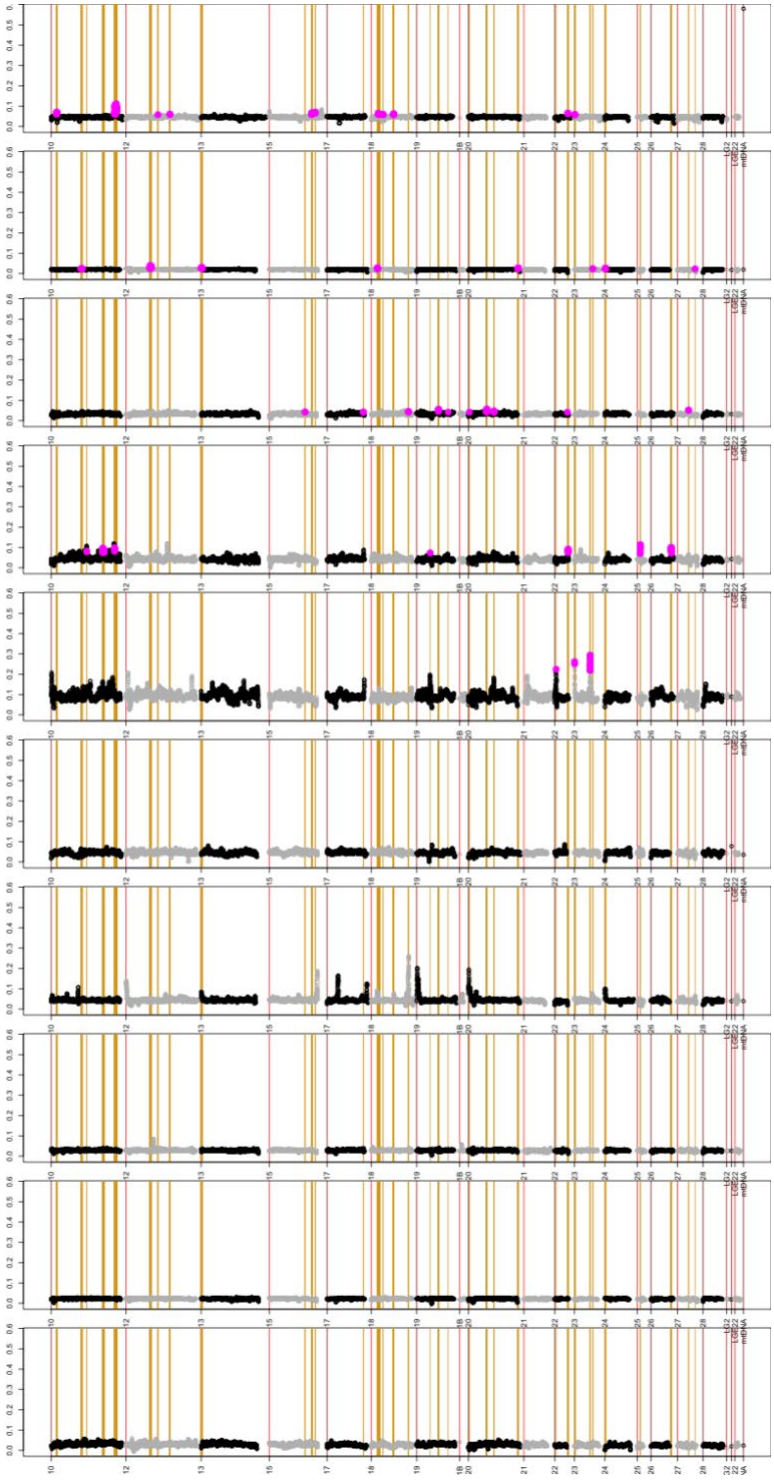
Supplementary Figure 4.6: Mean Dxy across the macro-chromosomes for all species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



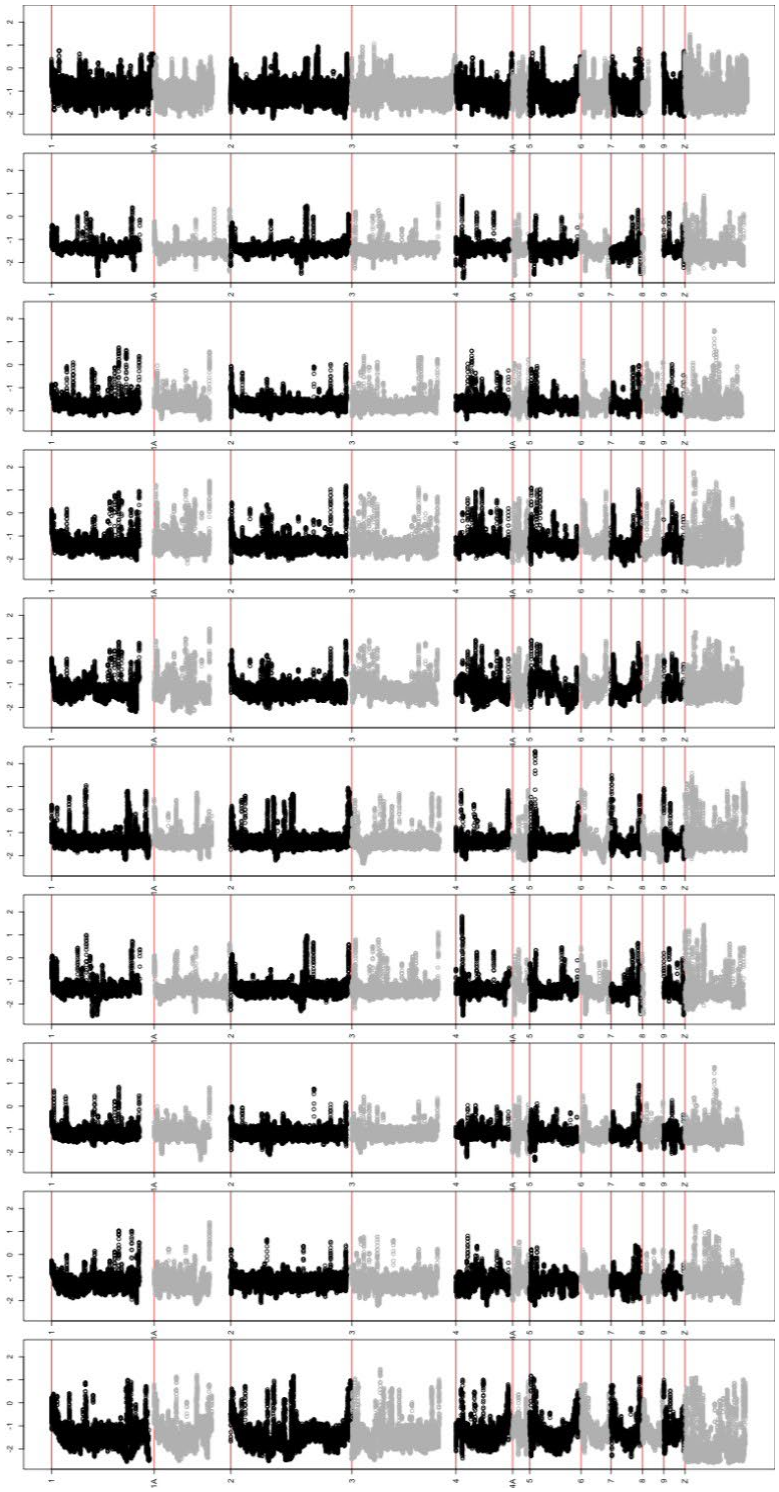
Supplementary Figure 4.7: Mean Dxy across the micro-chromosomes for all species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus*.



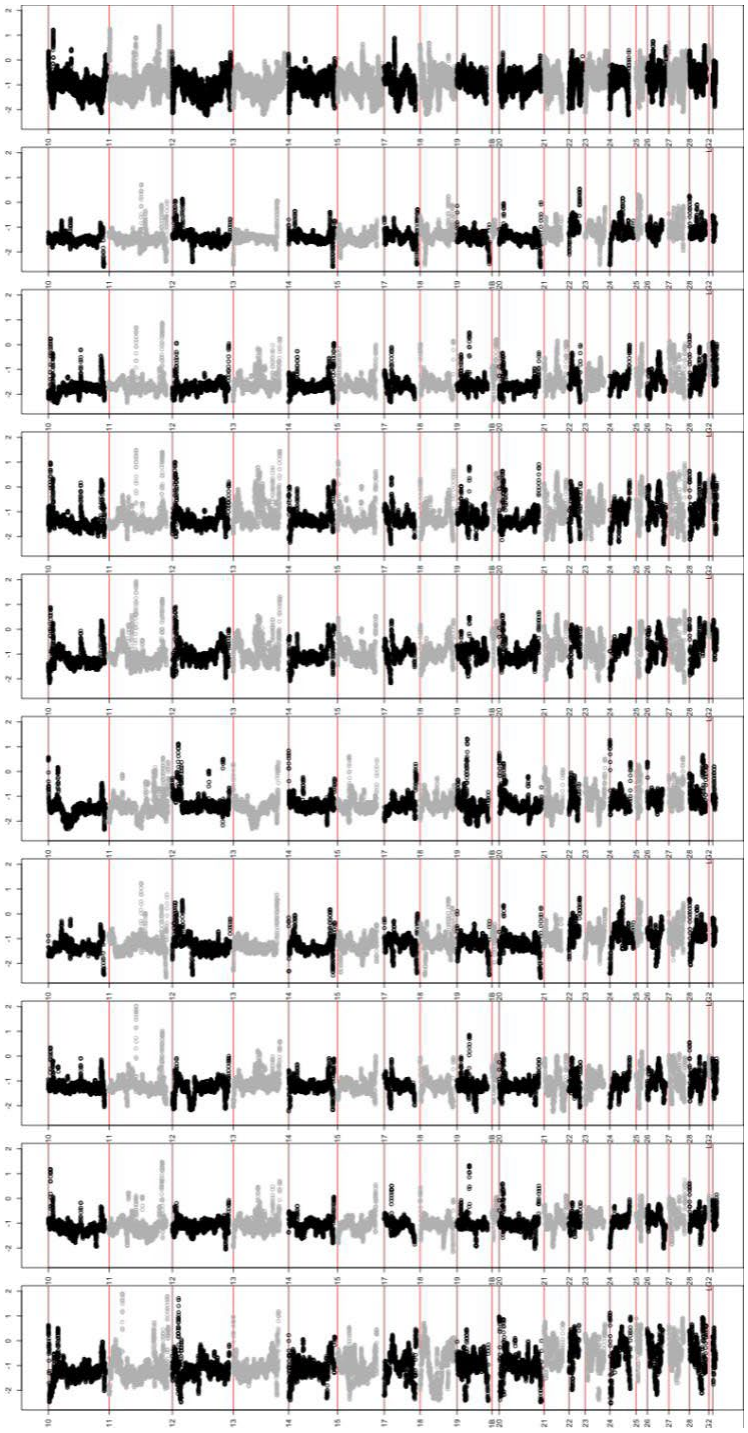
Supplementary Figure 4.8: locations of islands (cyan) and sweeps (magenta) for all species on the macro-chromosomes. Y-axis shows FST, x-axis shows a window. Gold lines behind points indicate regions where islands or sweeps are found on any species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



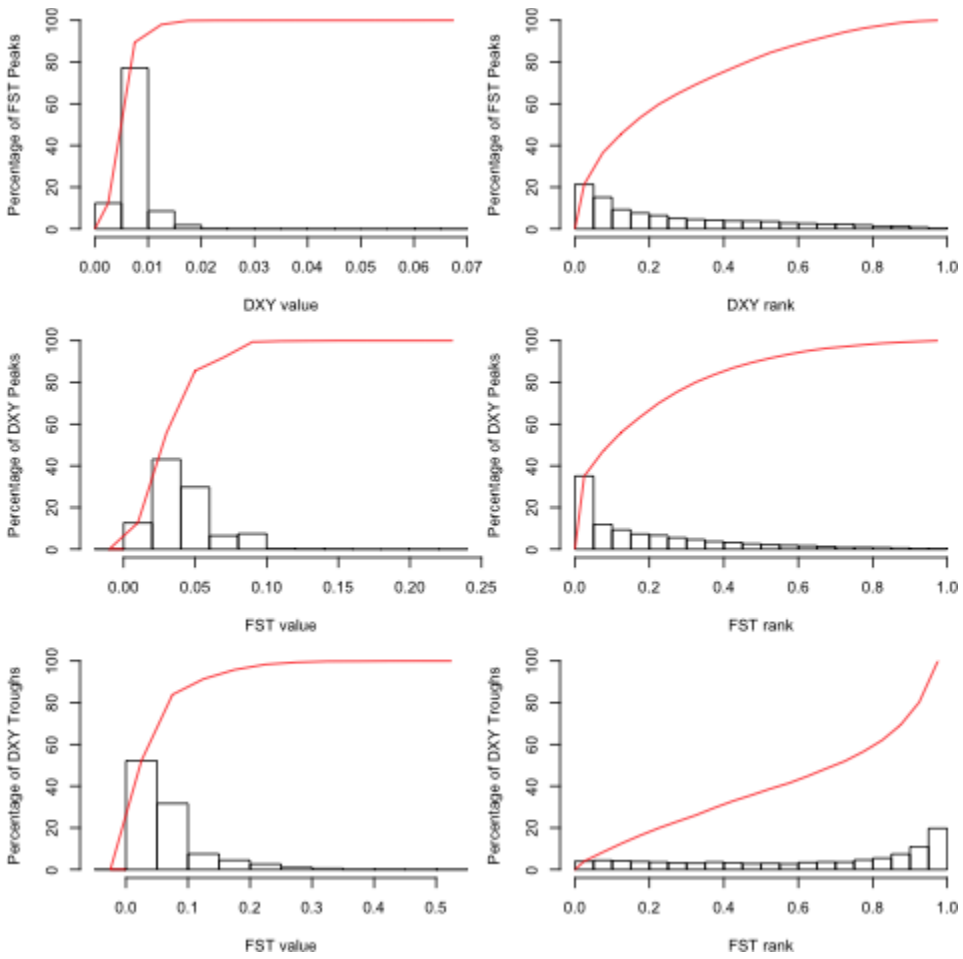
Supplementary Figure 4.9: locations of sweeps (magenta) for all species on the micro-chromosomes. Note that there are no islands. Y-axis shows FST, x-axis shows a window. Gold lines behind points indicate regions where islands or sweeps are found on any species. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



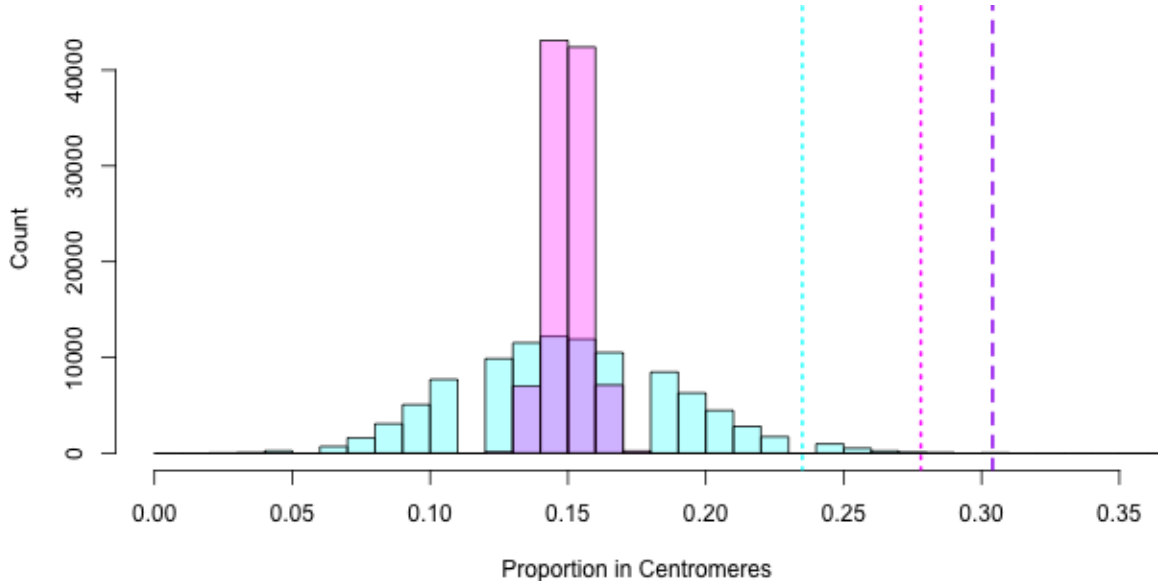
Supplementary Figure 4.10: Mean Tajima's D across the macro-chromosomes. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



Supplementary Figure 4.11: Mean Tajima's D across the micro-chromosomes. Top to bottom: *V. bellii, A. bilineata, C. brunneicapillus, T. crissale, T. curvirostre, A. flaviceps, M. fusca, P. melanura, P. nitens, C. sinuatus.*



Supplementary Figure 4.12: Comparisons between FST values, DXY values, FST peaks, and DXY peaks. Top: FST peaks by DXY values (left) and DXY rank (right). Middle: DXY peaks vs FST values (left) and FST rank (right). Bottom: DXY troughs vs FST values (left) and FST rank (right). Red lines are cumulative totals.



Supplementary Figure 4.13: Islands and sweeps are over-represented in the centromeres. X-axis is the simulated proportion of islands and sweeps in the centromeres. Y-axis is the number of simulations that fell within a given position. Pink bars show values for sweeps (N=2,960), blue bars for islands (N=83), and the purple indicates where they overlap. Vertical lines are the empirical estimates of the proportions within centromeres. Purple dashed line shows proportion of total windows that are in centromeres for both islands and sweeps. Pink dotted line shows proportion of total regions that are in centromeres for sweeps. Blue dotted line shows proportions of total regions that are in centromeres for islands.

APPENDIX D: SPECIMENS USED

Supplementary Table 5.1: Specimens used for morphometric analyses in Chapter III.

Catalog Number	Taxon	Lat.	Long.
AMNH J-023	*Amphispiza bilineata*	32.71	-108.4
AMNH J-069	*Amphispiza bilineata*	32.11	-107.6
AMNH J-092	*Amphispiza bilineata*	31.99	-107.2
AMNH J-093	*Amphispiza bilineata*	31.99	-107.2
AMNH J-095	*Amphispiza bilineata*	32.99	-107.2
AMNH J-096	*Amphispiza bilineata*	32.99	-107.2
AMNH J-130	*Amphispiza bilineata*	30.8	-105.01
AMNH SKIN 28378	*Amphispiza bilineata*	32.98	-111.33
AMNH SKIN 28385	*Amphispiza bilineata*	32.98	-111.33
AMNH SKIN 28397	*Amphispiza bilineata*	32.42	-110.63
AMNH SKIN 56356	*Amphispiza bilineata*	31	-109
MSB SKIN 29306	*Amphispiza bilineata*	32.28	-104.6
MSB SKIN 29308	*Amphispiza bilineata*	32.26	-104.49
MSB SKIN 29316	*Amphispiza bilineata*	32.26	-104.49
MSB SKIN 4574	*Amphispiza bilineata*	32.35	-103.79
MSB SKIN 5186	*Amphispiza bilineata*	32.36	-103.78
MSB SKIN 5187	*Amphispiza bilineata*	32.34	-103.84
AMNH SKIN 401809	*Amphispiza bilineata*	25.95	-97.51
AMNH SKIN 401811	*Amphispiza bilineata*	27.2	-98.1
AMNH SKIN 401812	*Amphispiza bilineata*	27.2	-98.1
AMNH SKIN 401865	*Amphispiza bilineata*	27.53	-99.48
AMNH SKIN 518495	*Amphispiza bilineata*	30.7	-101.9
AMNH SKIN 518501	*Amphispiza bilineata*	30.7	-101.9
AMNH SKIN 762584	*Amphispiza bilineata*	30.6	-103.89
AMNH SKIN 762591	*Amphispiza bilineata*	27.3	-102
AMNH SKIN 767122	*Amphispiza bilineata*	30.2	-97.6
AMNH SKIN 808103	*Amphispiza bilineata*	27.3	-102
AMNH SKIN 808104	*Amphispiza bilineata*	27.3	-102
AMNH SKIN 83861	*Amphispiza bilineata*	26.3	-98.8
AMNH SKIN 83862	*Amphispiza bilineata*	26.3	-98.8
AMNH SKIN 83894	*Amphispiza bilineata*	30.7	-101.9
DMNH 13222	*Amphispiza bilineata*	25.67	-101
DMNH 23604	*Amphispiza bilineata*	25.67	-101
DMNH 50993	*Amphispiza bilineata*	26.13	-97.4
DMNH 50994	*Amphispiza bilineata*	26	-97.2
DMNH 8790	*Amphispiza bilineata*	25.99	-97.45
UMMZ SKIN 55744	*Amphispiza bilineata*	26.46	-97.62
UMMZ SKIN 60426	*Amphispiza bilineata*	25.9	-97.5
AMNH SKIN 401840	*Amphispiza bilineata*	32.2	-110.87
AMNH SKIN 762598	*Amphispiza bilineata*	30	-115
AMNH SKIN 762607	*Amphispiza bilineata*	32.26	-110.87
AMNH SKIN 836849	*Amphispiza bilineata*	31.9	-109.2
DMNH 17379	*Amphispiza bilineata*	32.02	-109.33
DMNH 17380	*Amphispiza bilineata*	31.13	-109.32
DMNH 45328	*Amphispiza bilineata*	31.34	-110.93
DMNH 50996	*Amphispiza bilineata*	32.12	-110.81
DMNH 8796	*Amphispiza bilineata*	32.22	-110.93
DMNH 8797	*Amphispiza bilineata*	32.56	-110.68
DMNH 8798	*Amphispiza bilineata*	31.96	-109.31
UMMZ SKIN 3948	*Amphispiza bilineata*	31.13	-111.38
UMMZ SKIN 4278	*Amphispiza bilineata*	31.13	-111.38
UMMZ SKIN 55404	*Amphispiza bilineata*	34.74	-112.68
UMMZ SKIN 56857	*Amphispiza bilineata*	32.22	-110.93
UMMZ SKIN 57262	*Amphispiza bilineata*	31.49	-110.41
UMMZ SKIN 59879	*Amphispiza bilineata*	29.17	-103.15
UMMZ SKIN 59884	*Amphispiza bilineata*	29.17	-103.15
UMMZ SKIN 59886	*Amphispiza bilineata*	29.17	-103.15
UMMZ SKIN 59888	*Amphispiza bilineata*	29.17	-103.15
DMNH 50984	*Amphispiza bilineata*	25.27	-101.37

MSB SKIN 16241	*Amphispiza bilineata*	33.32	-106.08
AMNH J-007	*Auriparus flaviceps*	32.29	-112.86
AMNH J-016	*Auriparus flaviceps*	32.29	-112.86
AMNH J-019	*Auriparus flaviceps*	32.33	-112.79
AMNH J-028	*Auriparus flaviceps*	31.69	-108.4
AMNH J-037	*Auriparus flaviceps*	31.7	-108.44
AMNH J-038	*Auriparus flaviceps*	31.7	-108.44
AMNH J-108	*Auriparus flaviceps*	32.01	-107.1
AMNH J-128	*Auriparus flaviceps*	30.99	-104.87
AMNH J-153	*Auriparus flaviceps*	30.75	-105
AMNH SKIN 27422	*Auriparus flaviceps*	32.98	-111.33
AMNH SKIN 373566	*Auriparus flaviceps*	32.2	-110.8
AMNH SKIN 373569	*Auriparus flaviceps*	32.26	-110.87
AMNH SKIN 373584	*Auriparus flaviceps*	25.95	-97.51
AMNH SKIN 439066	*Auriparus flaviceps*	25.95	-97.51
AMNH SKIN 505626	*Auriparus flaviceps*	27.53	-99.48
AMNH SKIN 708827	*Auriparus flaviceps*	32.2	-110.6
AMNH SKIN 757255	*Auriparus flaviceps*	32.26	-110.87
AMNH SKIN 757263	*Auriparus flaviceps*	32.26	-110.87
AMNH SKIN 768782	*Auriparus flaviceps*	32.3	-110.7
AMNH SKIN 86444	*Auriparus flaviceps*	26.37	-98.82
AMNH SKIN 86447	*Auriparus flaviceps*	26.3	-98.8
AMNH SKIN 86475	*Auriparus flaviceps*	26.21	-98.33
AMNH SKIN 86476	*Auriparus flaviceps*	26.21	-98.33
AMNH SKIN 86492	*Auriparus flaviceps*	32.48	-110.9
AMNH SKIN 86496	*Auriparus flaviceps*	22.9	-98.9
MSB SKIN 2413	*Auriparus flaviceps*	34.12	-106.88
MSB SKIN 4603	*Auriparus flaviceps*	32.98	-105.93
UWBM 41248	*Auriparus flaviceps*	29.56343	-102.89763
UMMZ SKIN 160181	*Auriparus flaviceps*	33.57	-116.08
DMNH 29537	*Auriparus flaviceps*	35.05	-114.62
UMMZ SKIN 95667	*Auriparus flaviceps*	22.88	-109.92
CU 12475	*Auriparus flaviceps*	30.21	-103.24
DMNH 12583	*Auriparus flaviceps*	25.67	-101
DMNH 1424	*Auriparus flaviceps*	31.91	-109.09
DMNH 22761	*Auriparus flaviceps*	25.67	-101
DMNH 29529	*Auriparus flaviceps*	33.64	-111.67
DMNH 29531	*Auriparus flaviceps*	35.18	-114.42
DMNH 29534	*Auriparus flaviceps*	33.45	-112.07
DMNH 46072	*Auriparus flaviceps*	33.51	-111.9
DMNH 51693	*Auriparus flaviceps*	28.02	-100.86
DMNH 7240	*Auriparus flaviceps*	32.26	-110.87
AMNH J-009	*Campylorhynchus brunneicapillus*	32.29	-112.86
AMNH J-024	*Campylorhynchus brunneicapillus*	32.71	-108.4
AMNH J-034	*Campylorhynchus brunneicapillus*	31.69	-108.4
AMNH J-060	*Campylorhynchus brunneicapillus*	32.11	-107.60438
AMNH J-063	*Campylorhynchus brunneicapillus*	32.11	-107.6
AMNH SKIN 27592	*Campylorhynchus brunneicapillus*	32.98	-111.33
AMNH SKIN 27613	*Campylorhynchus brunneicapillus*	32.98	-111.33
AMNH SKIN 326476	*Campylorhynchus brunneicapillus*	31.4	-111.5
AMNH SKIN 374940	*Campylorhynchus brunneicapillus*	32.2	-110.87
AMNH SKIN 374941	*Campylorhynchus brunneicapillus*	32.2	-110.87
AMNH SKIN 374942	*Campylorhynchus brunneicapillus*	32.2	-110.87
AMNH SKIN 85866	*Campylorhynchus brunneicapillus*	26.3	-98.8
AMNH SKIN 85876	*Campylorhynchus brunneicapillus*	26.3	-98.8
AMNH SKIN 85877	*Campylorhynchus brunneicapillus*	26.3	-98.8
AMNH SKIN 85878	*Campylorhynchus brunneicapillus*	26.3	-98.8
AMNH SKIN 85882	*Campylorhynchus brunneicapillus*	26.3	-98.8
UWBM 90714	*Campylorhynchus brunneicapillus*	34.215539	-117.269592
AMNH J-080	*Cardinalis sinuatus*	32.11	-107.6
MSB SKIN 14262	*Cardinalis sinuatus*	34.18	-103.35
MSB SKIN 21242	*Cardinalis sinuatus*	32.33	-103.24
MSB SKIN 21243	*Cardinalis sinuatus*	32.11	-103.24
MSB SKIN 3707	*Cardinalis sinuatus*	32.13	-103.49

MSB SKIN 5200	*Cardinalis sinuatus*	32.38	-103.72
MSB SKIN 6480	*Cardinalis sinuatus*	32.05	-109.04
MSB SKIN 8813	*Cardinalis sinuatus*	33.39	-103.81
AMNH SKIN 760883	*Cardinalis sinuatus*	32.2	-110.87
AMNH SKIN 760885	*Cardinalis sinuatus*	32.26	-110.87
AMNH SKIN 760886	*Cardinalis sinuatus*	32.26	-110.87
AMNH SKIN 760887	*Cardinalis sinuatus*	32.26	-110.87
AMNH SKIN 760888	*Cardinalis sinuatus*	32.26	-110.87
AMNH SKIN 760890	*Cardinalis sinuatus*	27	-98
AMNH SKIN 84270	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84271	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84272	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84274	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84311	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84312	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84315	*Cardinalis sinuatus*	26.3	-98.8
AMNH SKIN 84323	*Cardinalis sinuatus*	31.2	-98.3
AMNH SKIN 84330	*Cardinalis sinuatus*	26.21	-98.33
DMNH 13114	*Cardinalis sinuatus*	25.67	-101
DMNH 23501	*Cardinalis sinuatus*	25.67	-101
DMNH 23503	*Cardinalis sinuatus*	25.67	-101
DMNH 48438	*Cardinalis sinuatus*	25.43	-100.94
MSB SKIN 8810	*Cardinalis sinuatus*	32.05	-109.04
AMNH J-058	*Melozone fusca*	32.11	-107.6
AMNH J-098	*Melozone fusca*	31.99	-107.2
AMNH J-100	*Melozone fusca*	32.99	-107.2
AMNH SKIN 326500	*Melozone fusca*	31.4	-111.5
AMNH SKIN 461707	*Melozone fusca*	31.95	-109.18
AMNH SKIN 808359	*Melozone fusca*	32.2	-110.8
MSB SKIN 26936	*Melozone fusca*	33.97	-107.25
UWBM 48497	*Melozone fusca*	33.37	-111.62
UWBM 82734	*Melozone fusca*	26.275	-108.795
UWBM 84066	*Melozone fusca*	26.31	-108.81
AMNH SKIN 28207	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28211	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28213	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28215	*Melozone fusca*	34.3	-111.6
AMNH SKIN 28218	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28219	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28223	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28230	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28235	*Melozone fusca*	32.98	-111.33
AMNH SKIN 28549	*Melozone fusca*	32.98	-111.33
AMNH SKIN 368649	*Melozone fusca*	31.49	-110.41
AMNH SKIN 368650	*Melozone fusca*	31.49	-110.41
AMNH SKIN 368666	*Melozone fusca*	32.2	-110.87
AMNH SKIN 368667	*Melozone fusca*	32.2	-110.87
AMNH SKIN 368686	*Melozone fusca*	30.6	-103.89
AMNH SKIN 368687	*Melozone fusca*	30.6	-103.89
AMNH SKIN 368690	*Melozone fusca*	30.9	-99.7
AMNH SKIN 368691	*Melozone fusca*	30.9	-99.7
AMNH SKIN 41634	*Melozone fusca*	32.7	-108.2
AMNH SKIN 41636	*Melozone fusca*	32.26	-110.87
AMNH SKIN 41637	*Melozone fusca*	34.3	-105.9
AMNH SKIN 53038	*Melozone fusca*	34.56	-111.85
AMNH SKIN 53039	*Melozone fusca*	34.56	-111.85
AMNH SKIN 53042	*Melozone fusca*	34.56	-111.85
AMNH SKIN 53043	*Melozone fusca*	34.56	-111.85
AMNH SKIN 53044	*Melozone fusca*	34.2	-111.3
AMNH SKIN 56313	*Melozone fusca*	31.43	-109.9
AMNH SKIN 56858	*Melozone fusca*	32.5	-117
AMNH SKIN 761997	*Melozone fusca*	31.49	-110.41
AMNH SKIN 84206	*Melozone fusca*	30.6	-103.89
AMNH SKIN 84207	*Melozone fusca*	30.6	-103.89

AMNH SKIN 842073	*Melozone fusca*	30.78	-105.02
AMNH SKIN 84208	*Melozone fusca*	30.6	-103.89
AMNH SKIN 84209	*Melozone fusca*	30.6	-103.89
AMNH SKIN 84213	*Melozone fusca*	30.6	-103.89
AMNH SKIN 84214	*Melozone fusca*	30.6	-103.89
AMNH SKIN 84217	*Melozone fusca*	31.4	-103.5
AMNH SKIN 84218	*Melozone fusca*	30.1	-104.2
AMNH SKIN 98979	*Melozone fusca*	32.2	-110.87
CU 30208	*Melozone fusca*	32.26	-110.88
DMNH 1427	*Melozone fusca*	31.91	-109.09
DMNH 45192	*Melozone fusca*	31.34	-110.93
DMNH 48948	*Melozone fusca*	31.71	-110.07
DMNH 48949	*Melozone fusca*	31.72	-110.74
DMNH 8762	*Melozone fusca*	31.96	-109.31
UMMZ SKIN 55043	*Melozone fusca*	31.93	-109.22
UMMZ SKIN 55382	*Melozone fusca*	31.49	-110.41
AMNH J-004	*Phainopepla nitens*	32.29	-112.86
AMNH J-011	*Phainopepla nitens*	32.29	-112.86
AMNH J-012	*Phainopepla nitens*	32.29	-112.86
AMNH J-015	*Phainopepla nitens*	32.29	-112.86
AMNH SKIN 92562	*Phainopepla nitens*	26	-105.8
AMNH SKIN 92565	*Phainopepla nitens*	26	-105.8
AMNH SKIN 92567	*Phainopepla nitens*	26	-105.8
MSB SKIN 15840	*Phainopepla nitens*	33.37	-105.94
MSB SKIN 29255	*Phainopepla nitens*	32.82	-107.3
MSB SKIN 349	*Phainopepla nitens*	31.41	-108.78
MSB SKIN 44074	*Phainopepla nitens*	33.63	-107.01
MSB SKIN 44075	*Phainopepla nitens*	33.68	-107
UMMZ SKIN 65240	*Phainopepla nitens*	29.85	-103.51
AMNH SKIN 28059	*Phainopepla nitens*	32.98	-111.33
AMNH SKIN 53282	*Phainopepla nitens*	34.56	-111.85
AMNH SKIN 53290	*Phainopepla nitens*	34.56	-111.85
AMNH SKIN 53301	*Phainopepla nitens*	33.3	-110.4
AMNH SKIN 53309	*Phainopepla nitens*	34.56	-111.85
AMNH SKIN 706908	*Phainopepla nitens*	22.4	-100.3
AMNH SKIN 706909	*Phainopepla nitens*	22.4	-100.3
AMNH SKIN 92569	*Phainopepla nitens*	26	-105.8
AMNH SKIN 92570	*Phainopepla nitens*	26	-105.8
CU 14455	*Phainopepla nitens*	30.04	-103.27
AMNH SKIN 706910	*Phainopepla nitens*	22.4	-100.3
AMNH J-014	*Polioptila melanura*	32.29	-112.86
AMNH J-129	*Polioptila melanura*	30.8	-105.01
AMNH J-136	*Polioptila melanura*	30.73	-104.99
AMNH J-139	*Polioptila melanura*	30.75	-105
AMNH J-144	*Polioptila melanura*	30.75	-104.97
AMNH J-150	*Polioptila melanura*	30.75	-105
AMNH SKIN 39349	*Polioptila melanura*	32.26	-110.87
AMNH SKIN 86584	*Polioptila melanura*	26.3	-98.8
AMNH SKIN 86585	*Polioptila melanura*	26.3	-98.8
AMNH SKIN 86586	*Polioptila melanura*	26.3	-98.8
AMNH SKIN 86596	*Polioptila melanura*	30	-104.2
AMNH SKIN 86602	*Polioptila melanura*	27.53	-99.48
MSB SKIN 14033	*Polioptila melanura*	32.05	-109.04
MSB SKIN 29257	*Polioptila melanura*	32.82	-107.3
DMNH 30293	*Polioptila melanura*	34.99	-113.49
DMNH 30298	*Polioptila melanura*	32.08	-110.79
DMNH 30299	*Polioptila melanura*	32.22	-110.79
DMNH 30304	*Polioptila melanura*	33.4	-110.39
DMNH 30305	*Polioptila melanura*	33.03	-109.27
DMNH 30307	*Polioptila melanura*	32.08	-111.56
DMNH 30310	*Polioptila melanura*	32.26	-110.87
DMNH 30313	*Polioptila melanura*	33.42	-110.45
DMNH 46236	*Polioptila melanura*	33.51	-111.9
DMNH 52160	*Polioptila melanura*	25.45	-101.32

DMNH 7666	*Polioptila melanura*	33.45	-112.07
MSB SKIN 18796	*Polioptila melanura*	32.62	-106.93
MSB SKIN 19566	*Polioptila melanura*	32.69	-108.97
AMNH SKIN 377584	*Polioptila melanura*	31.9	-110.3
AMNH SKIN 377595	*Polioptila melanura*	32.2	-110.87
AMNH SKIN 808213	*Polioptila melanura*	32.3	-110.8
AMNH SKIN 86609	*Polioptila melanura*	32.98	-111.33
CU 13987	*Polioptila melanura*	30.21	-103.24
AMNH J-017	*Toxostoma crissale*	32.33	-112.79
AMNH SKIN 53658	*Toxostoma crissale*	34.56	-111.85
AMNH SKIN 78297	*Toxostoma crissale*	32	-106.6
AMNH SKIN 85855	*Toxostoma crissale*	32.5	-110.8
MSB SKIN 21023	*Toxostoma crissale*	35.36	-106.15
MSB SKIN 4564	*Toxostoma crissale*	32.33	-103.77
MSB SKIN 5141	*Toxostoma crissale*	32.34	-103.84
MSB SKIN 5142	*Toxostoma crissale*	32.34	-103.83
AMNH SKIN 406445	*Toxostoma crissale*	31.8	-110.4
AMNH SKIN 406446	*Toxostoma crissale*	31.8	-110.4
AMNH SKIN 406456	*Toxostoma crissale*	32.2	-110.87
AMNH SKIN 446844	*Toxostoma crissale*	32.7	-108.3
AMNH SKIN 446845	*Toxostoma crissale*	32.7	-108.3
AMNH SKIN 446846	*Toxostoma crissale*	32.7	-108.3
AMNH SKIN 53651	*Toxostoma crissale*	32.2	-107.7
AMNH SKIN 53652	*Toxostoma crissale*	32.2	-107.7
AMNH SKIN 53654	*Toxostoma crissale*	34.56	-111.85
AMNH SKIN 758127	*Toxostoma crissale*	32.6	-114.6
AMNH SKIN 78292	*Toxostoma crissale*	32.1	-106.7
AMNH SKIN 85856	*Toxostoma crissale*	32.98	-111.33
AMNH SKIN 85857	*Toxostoma crissale*	32.98	-111.33
AMNH SKIN 85859	*Toxostoma crissale*	32.5	-110.8
CU 13631	*Toxostoma crissale*	30.04	-103.27
CU 13635	*Toxostoma crissale*	30.02	-103.24
CU 13636	*Toxostoma crissale*	30.03	-103.24
UMMZ SKIN 59771	*Toxostoma crissale*	29.25	-103.28
UMMZ SKIN 86184	*Toxostoma crissale*	29.09	-103.09
DMNH 49780	*Toxostoma crissale*	25.02	-101.02
AMNH J-003	*Toxostoma curvirostre*	32.29	-112.81
AMNH J-050	*Toxostoma curvirostre*	31.7	-108.44
AMNH J-081	*Toxostoma curvirostre*	32.11	-107.6
AMNH J-089	*Toxostoma curvirostre*	32.99	-107.2
AMNH J-126	*Toxostoma curvirostre*	32.04	-107.05
MSB SKIN 19093	*Toxostoma curvirostre*	32.14	-104.43
MSB SKIN 23226	*Toxostoma curvirostre*	35.04	-106.67
MSB SKIN 24894	*Toxostoma curvirostre*	35.3	-106.77
MSB SKIN 3149	*Toxostoma curvirostre*	34.23	-105.99
MSB SKIN 3153	*Toxostoma curvirostre*	34.22	-105.99
MSB SKIN 3509	*Toxostoma curvirostre*	35.32	-104.3
MSB SKIN 3510	*Toxostoma curvirostre*	35.19	-106.17
DMNH 22895	*Toxostoma curvirostre*	25.18	-101.08
UMMZ SKIN 55373	*Toxostoma curvirostre*	31.49	-110.41
AMNH SKIN 375786	*Toxostoma curvirostre*	25.95	-97.51
AMNH SKIN 375788	*Toxostoma curvirostre*	25.95	-97.51
AMNH SKIN 375789	*Toxostoma curvirostre*	25.95	-97.51
AMNH SKIN 375790	*Toxostoma curvirostre*	25.95	-97.51
AMNH SKIN 375800	*Toxostoma curvirostre*	25.95	-97.51
AMNH SKIN 85811	*Toxostoma curvirostre*	26.3	-98.8
AMNH SKIN 85812	*Toxostoma curvirostre*	26.3	-98.8
AMNH SKIN 85823	*Toxostoma curvirostre*	26.21	-98.33
AMNH SKIN 85829	*Toxostoma curvirostre*	27.53	-99.48
DMNH 12741	*Toxostoma curvirostre*	25.67	-101
DMNH 12742	*Toxostoma curvirostre*	25.67	-101
DMNH 12743	*Toxostoma curvirostre*	25.67	-101
AMNH SKIN 27710	*Toxostoma curvirostre*	32.98	-111.33
AMNH SKIN 27711	*Toxostoma curvirostre*	32.98	-111.33

AMNH SKIN 27721	*Toxostoma curvirostre*	32.98	-111.33
AMNH SKIN 27727	*Toxostoma curvirostre*	32.98	-111.33
AMNH SKIN 375766	*Toxostoma curvirostre*	32.2	-110.87
AMNH SKIN 375784	*Toxostoma curvirostre*	31.8	-110.4
AMNH SKIN 758067	*Toxostoma curvirostre*	31.49	-110.41
AMNH SKIN 85847	*Toxostoma curvirostre*	32.98	-111.33
DMNH 35977	*Toxostoma curvirostre*	33.55	-111.95
DMNH 46088	*Toxostoma curvirostre*	32.22	-110.93
DMNH 7474	*Toxostoma curvirostre*	32.26	-110.87
DMNH 7475	*Toxostoma curvirostre*	32.26	-110.87
DMNH 7477	*Toxostoma curvirostre*	32.26	-110.87
DMNH 7478	*Toxostoma curvirostre*	32.26	-110.87
UMMZ SKIN 280	*Toxostoma curvirostre*	32.83	-111.13
AMNH J-018	*Vireo bellii*	32.33	-112.79
AMNH J-127	*Vireo bellii*	30.99	-104.87
MSB SKIN 14356	*Vireo bellii*	32.97	-108.58
UWBM 81294	*Vireo bellii*	26.304	-108.699
UWBM 88987	*Vireo bellii*	26.3155	-108.6989
UWBM 88988	*Vireo bellii*	26.3155	-108.6989
AMNH SKIN 27978	*Vireo bellii*	32.98	-111.33
AMNH SKIN 27981	*Vireo bellii*	32.98	-111.33
AMNH SKIN 27982	*Vireo bellii*	32.98	-111.33
AMNH SKIN 378991	*Vireo bellii*	32.26	-110.87
AMNH SKIN 53342	*Vireo bellii*	34.56	-111.85
DMNH 26108	*Vireo bellii*	32.14	-110.69
DMNH 32263	*Vireo bellii*	34.92	-113.63
DMNH 32264	*Vireo bellii*	34.92	-113.63
DMNH 32266	*Vireo bellii*	31.35	-109.05
DMNH 32267	*Vireo bellii*	32.32	-110.83
DMNH 32268	*Vireo bellii*	32.26	-110.87
DMNH 50282	*Vireo bellii*	31.97	-110.96
DMNH 50283	*Vireo bellii*	31.97	-110.96
UMMZ SKIN 55195	*Vireo bellii*	32.22	-110.93
UMMZ SKIN 60309	*Vireo bellii*	34.56	-111.85
UMMZ SKIN 60310	*Vireo bellii*	34.54	-112.47
AMNH SKIN 378975	*Vireo bellii*	30.3	-97.7
AMNH SKIN 378976	*Vireo bellii*	30.9	-99.7
AMNH SKIN 378977	*Vireo bellii*	30.9	-99.7
AMNH SKIN 378979	*Vireo bellii*	30.9	-99.7
AMNH SKIN 378980	*Vireo bellii*	30.9	-99.7
AMNH SKIN 378981	*Vireo bellii*	30.9	-99.7
AMNH SKIN 378982	*Vireo bellii*	30.9	-99.7
AMNH SKIN 758926	*Vireo bellii*	33.6	-97.1
AMNH SKIN 758927	*Vireo bellii*	30.9	-99.7
DMNH 23085	*Vireo bellii*	26.82	-105.61
MSB SKIN 2414	*Vireo bellii*	34.12	-106.88
CU 15650	*Vireo bellii*	29.13	-103.51
UMMZ SKIN 163424	*Vireo bellii*	27.41	-112.51
DMNH 7812	*Vireo bellii*	32.64	-116.78
DMNH 7813	*Vireo bellii*	33.77	-116.56

Supplementary Table 5.2: Specimens used for sequencing in Chapter III and Chapter IV.

Catalog Number	Taxon	Lat.	Long.
AMNH KLP-28	*Amphispiza bilineata*	32.91	-109.49
AMNH KLP-40	*Amphispiza bilineata*	32.91	-109.49
AMNH J-0984	*Amphispiza bilineata*	32.64	-108.83
AMNH J-020	*Amphispiza bilineata*	32.71	-108.40
AMNH J-54	*Amphispiza bilineata*	32.11	-107.60
AMNH DOT-24706	*Amphispiza bilineata*	30.78	-105.02
AMNH DOT-24708	*Amphispiza bilineata*	30.78	-105.02
AMNH DOT-24774	*Amphispiza bilineata*	29.56	-103.81
LSUMZ 36269	*Amphispiza bilineata*	31.62	-105.18
MSB 24372	*Amphispiza bilineata*	32.04	-112.88
MSB 28940	*Amphispiza bilineata*	32.35	-106.60
MSB 29306	*Amphispiza bilineata*	32.28	-104.60
MSB 24591	*Amphispiza bilineata*	29.99	-103.56
MSB 24596	*Amphispiza bilineata*	29.99	-103.56
MSB 21396	*Amphispiza bilineata*	29.60	-103.00
MSB 21438	*Amphispiza bilineata*	29.60	-103.00
UWBM 77657	*Amphispiza bilineata*	31.51	-111.28
UWBM 77557	*Amphispiza bilineata*	31.53	-111.27
UWBM 77822	*Amphispiza bilineata*	32.22	-110.62
UWBM 111929	*Amphispiza bilineata*	31.76	-109.38
UWBM 77636	*Amphispiza bilineata*	31.80	-108.80
UWBM 77693	*Amphispiza bilineata*	31.80	-108.80
UWBM 77531	*Amphispiza bilineata*	31.80	-108.74
UWBM 114894	*Amphispiza bilineata*	29.60	-103.00
AMNH J-7	*Auriparus flaviceps*	32.29	-112.86
AMNH J-16	*Auriparus flaviceps*	32.29	-112.86
AMNH J-19	*Auriparus flaviceps*	32.33	-112.79
AMNH J-0965	*Auriparus flaviceps*	32.44	-111.46
AMNH J-0967	*Auriparus flaviceps*	32.44	-111.46
AMNH J-0968	*Auriparus flaviceps*	32.44	-111.46
AMNH KLP-51	*Auriparus flaviceps*	32.88	-109.50
AMNH LJM-150	*Auriparus flaviceps*	32.91	-109.49
AMNH LRM-37	*Auriparus flaviceps*	32.91	-109.49
AMNH J-0995	*Auriparus flaviceps*	32.60	-108.84
AMNH J-37	*Auriparus flaviceps*	31.70	-108.44
AMNH J-38	*Auriparus flaviceps*	31.70	-108.44
AMNH J-28	*Auriparus flaviceps*	31.69	-108.40
AMNH J-108	*Auriparus flaviceps*	32.01	-107.10
AMNH J-153	*Auriparus flaviceps*	30.75	-105.00
AMNH J-128	*Auriparus flaviceps*	30.99	-104.87
LSUMZ 15579	*Auriparus flaviceps*	30.00	-99.20
LSUMZ 8436	*Auriparus flaviceps*	28.80	-98.40
MSB 22493	*Auriparus flaviceps*	32.05	-109.04
TCWC 23805	*Auriparus flaviceps*	30.06	-103.50
UWBM 112147	*Auriparus flaviceps*	29.59	-103.00
UWBM 111637	*Auriparus flaviceps*	29.59	-103.00
AMNH J-9	*Campylorhynchus brunneicapillus*	32.29	-112.86
AMNH J-0972	*Campylorhynchus brunneicapillus*	32.44	-109.35
AMNH J-0987	*Campylorhynchus brunneicapillus*	32.64	-108.83
AMNH J-34	*Campylorhynchus brunneicapillus*	31.69	-108.40
AMNH DOT-24736	*Campylorhynchus brunneicapillus*	30.78	-105.02
LSUMZ 20006	*Campylorhynchus brunneicapillus*	32.39	-111.37
LSUMZ 62493	*Campylorhynchus brunneicapillus*	31.35	-104.90
MSB 29018	*Campylorhynchus brunneicapillus*	33.26	-113.88
MSB 26352	*Campylorhynchus brunneicapillus*	32.22	-108.99
MSB 39823	*Campylorhynchus brunneicapillus*	32.09	-107.59
MSB 22000	*Campylorhynchus brunneicapillus*	32.67	-107.29
MSB 29302	*Campylorhynchus brunneicapillus*	32.26	-104.49
MSB 25299	*Campylorhynchus brunneicapillus*	32.46	-103.90
MSB 24490	*Campylorhynchus brunneicapillus*	29.99	-103.56
MSB 24527	*Campylorhynchus brunneicapillus*	29.99	-103.56

MSB 24627	*Campylorhynchus brunneicapillus*	29.99	-103.56
MSB 24629	*Campylorhynchus brunneicapillus*	29.99	-103.56
UWBM 77526	*Campylorhynchus brunneicapillus*	31.80	-110.79
UWBM 77602	*Campylorhynchus brunneicapillus*	31.80	-110.79
UWBM 77884	*Campylorhynchus brunneicapillus*	32.34	-109.74
UWBM 77990	*Campylorhynchus brunneicapillus*	32.00	-109.20
UWBM 77991	*Campylorhynchus brunneicapillus*	32.00	-109.20
AMNH J-0961	*Cardinalis sinuatus*	32.44	-111.46
AMNH J-0962	*Cardinalis sinuatus*	32.44	-111.46
AMNH DOT-3731	*Cardinalis sinuatus*	31.90	-109.16
AMNH J-0999	*Cardinalis sinuatus*	31.65	-108.33
AMNH J-80	*Cardinalis sinuatus*	32.11	-107.60
AMNH J-132	*Cardinalis sinuatus*	30.75	-105.00
AMNH DOT-24767	*Cardinalis sinuatus*	29.56	-103.81
AMNH DOT-24766	*Cardinalis sinuatus*	29.56	-103.81
AMNH DOT-24791	*Cardinalis sinuatus*	29.56	-103.81
LSUMZ 17193	*Cardinalis sinuatus*	31.56	-105.18
MSB 25201	*Cardinalis sinuatus*	32.06	-112.71
MSB 18064	*Cardinalis sinuatus*	32.05	-109.04
MSB 24457	*Cardinalis sinuatus*	29.99	-103.56
MSB 24612	*Cardinalis sinuatus*	29.99	-103.56
TCWC 16576	*Cardinalis sinuatus*	30.16	-103.23
TCWC 16314	*Cardinalis sinuatus*	31.40	-102.37
UWBM 103346	*Cardinalis sinuatus*	31.48	-111.34
UWBM 77548	*Cardinalis sinuatus*	32.21	-109.18
UWBM 77718	*Cardinalis sinuatus*	32.21	-109.18
UWBM 77780	*Cardinalis sinuatus*	32.21	-109.18
UWBM 77781	*Cardinalis sinuatus*	32.21	-109.18
UWBM 100163	*Cardinalis sinuatus*	29.60	-103.00
UWBM 105429	*Cardinalis sinuatus*	29.60	-103.00
UWBM 109277	*Cardinalis sinuatus*	29.60	-103.00
UWBM 109278	*Cardinalis sinuatus*	29.60	-103.00
AMNH J-0971	*Melozone fusca*	32.24	-109.34
AMNH J-0992	*Melozone fusca*	32.59	-108.82
AMNH J-1005	*Melozone fusca*	31.62	-108.37
AMNH J-98	*Melozone fusca*	31.99	-107.20
AMNH DOT-24751	*Melozone fusca*	30.78	-105.02
AMNH DOT-24758	*Melozone fusca*	30.78	-105.02
AMNH DOT-24697	*Melozone fusca*	30.78	-105.02
LSUMZ 78587	*Melozone fusca*	30.68	-104.04
LSUMZ 16732	*Melozone fusca*	30.40	-100.50
MSB 41397	*Melozone fusca*	33.43	-108.09
MSB 39814	*Melozone fusca*	32.09	-107.59
MSB 39815	*Melozone fusca*	32.09	-107.59
MSB 29301	*Melozone fusca*	32.11	-104.73
MSB 24608	*Melozone fusca*	29.99	-103.56
TCWC 15842	*Melozone fusca*	30.91	-102.62
UWBM 95906	*Melozone fusca*	31.48	-111.34
UWBM 95907	*Melozone fusca*	31.48	-111.34
UWBM 77790	*Melozone fusca*	31.45	-111.25
UWBM 95909	*Melozone fusca*	31.72	-110.78
UWBM 77873	*Melozone fusca*	31.51	-110.72
UWBM 77870	*Melozone fusca*	31.53	-110.71
UWBM 77951	*Melozone fusca*	31.59	-110.04
UWBM 77992	*Melozone fusca*	32.00	-109.20
UWBM 78059	*Melozone fusca*	32.87	-109.19
AMNH J-4	*Phainopepla nitens*	32.29	-112.86
AMNH J-11	*Phainopepla nitens*	32.29	-112.86
AMNH J-12	*Phainopepla nitens*	32.29	-112.86
AMNH J-13	*Phainopepla nitens*	32.29	-112.86
AMNH J-15	*Phainopepla nitens*	32.29	-112.86
LSUMZ 52747	*Phainopepla nitens*	30.60	-104.00
LSUMZ 64140	*Phainopepla nitens*	30.60	-104.00
LSUMZ 64141	*Phainopepla nitens*	30.60	-104.00

LSUMZ 64233	*Phainopepla nitens*	29.50	-103.00
MSB 29255	*Phainopepla nitens*	32.82	-107.30
MSB 29847	*Phainopepla nitens*	32.82	-107.30
MSB 40683	*Phainopepla nitens*	33.62	-107.01
MSB 44074	*Phainopepla nitens*	33.63	-107.01
MSB 44075	*Phainopepla nitens*	33.68	-107.00
MSB 39010	*Phainopepla nitens*	34.00	-106.99
UWBM 115608	*Phainopepla nitens*	32.84	-114.44
UWBM 115563	*Phainopepla nitens*	34.10	-114.10
UWBM 77527	*Phainopepla nitens*	31.80	-110.79
UWBM 77633	*Phainopepla nitens*	31.52	-108.98
UWBM 77634	*Phainopepla nitens*	31.52	-108.98
AMNH J-1	*Polioptila melanura*	32.29	-112.81
AMNH J-963	*Polioptila melanura*	32.44	-111.46
AMNH LJM-170	*Polioptila melanura*	32.91	-109.49
AMNH J-26	*Polioptila melanura*	31.69	-108.40
AMNH J-1020	*Polioptila melanura*	32.04	-107.57
AMNH J-129	*Polioptila melanura*	30.80	-105.01
AMNH J-139	*Polioptila melanura*	30.75	-105.00
AMNH DOT-24769	*Polioptila melanura*	29.56	-103.81
AMNH DOT-24787	*Polioptila melanura*	29.56	-103.81
LSUMZ 61914	*Polioptila melanura*	34.80	-116.10
LSUMZ 34177	*Polioptila melanura*	31.56	-105.18
MSB 29366	*Polioptila melanura*	33.26	-113.88
MSB 29367	*Polioptila melanura*	33.26	-113.88
MSB 19565	*Polioptila melanura*	32.69	-108.97
MSB 29256	*Polioptila melanura*	32.82	-107.30
MSB 29257	*Polioptila melanura*	32.82	-107.30
UWBM 100358	*Polioptila melanura*	32.84	-114.45
UWBM 108999	*Polioptila melanura*	32.84	-114.45
UWBM 111997	*Polioptila melanura*	32.84	-114.45
UWBM 112009	*Polioptila melanura*	32.84	-114.45
UWBM 112658	*Polioptila melanura*	32.84	-114.45
UWBM 112130	*Polioptila melanura*	29.60	-103.00
UWBM 112138	*Polioptila melanura*	29.60	-103.00
AMNH J-17	*Toxostoma crissale*	32.33	-112.79
AMNH DOT-3738	*Toxostoma crissale*	31.87	-109.06
AMNH J-1015	*Toxostoma crissale*	31.70	-108.44
AMNH J-1023	*Toxostoma crissale*	32.04	-107.57
AMNH J-107	*Toxostoma crissale*	32.01	-107.10
AMNH DOT-24713	*Toxostoma crissale*	30.78	-105.02
LSUMZ 16582	*Toxostoma crissale*	32.21	-109.18
LSUMZ 16586	*Toxostoma crissale*	32.21	-109.18
LSUMZ 47509	*Toxostoma crissale*	32.05	-109.04
LSUMZ 47510	*Toxostoma crissale*	32.05	-109.04
LSUMZ 40753	*Toxostoma crissale*	30.60	-104.00
LSUMZ 47304	*Toxostoma crissale*	30.60	-104.00
LSUMZ 58267	*Toxostoma crissale*	30.60	-104.00
LSUMZ 51732	*Toxostoma crissale*	29.50	-103.00
MSB 20926	*Toxostoma crissale*	34.35	-106.88
MSB 26421	*Toxostoma crissale*	34.34	-106.87
MSB 21308	*Toxostoma crissale*	29.60	-103.00
TCWC 23990	*Toxostoma crissale*	31.27	-104.91
UWBM 109226	*Toxostoma crissale*	32.84	-114.44
UWBM 115562	*Toxostoma crissale*	32.84	-114.44
UWBM 77981	*Toxostoma crissale*	32.90	-109.22
UWBM 77984	*Toxostoma crissale*	32.87	-109.19
AMNH J-3	*Toxostoma curvirostre*	32.29	-112.81
AMNH J-50	*Toxostoma curvirostre*	31.70	-108.44
AMNH J-81	*Toxostoma curvirostre*	32.11	-107.60
AMNH J-89	*Toxostoma curvirostre*	31.99	-107.20
AMNH J-126	*Toxostoma curvirostre*	32.04	-107.05
LSUMZ 16593	*Toxostoma curvirostre*	32.39	-111.37
LSUMZ 9910	*Toxostoma curvirostre*	31.80	-110.79

LSUMZ 18961	*Toxostoma curvirostre*	31.80	-110.79
LSUMZ 58304	*Toxostoma curvirostre*	31.35	-104.90
MSB 24783	*Toxostoma curvirostre*	31.81	-110.59
MSB 24262	*Toxostoma curvirostre*	32.19	-104.66
MSB 29272	*Toxostoma curvirostre*	30.68	-104.04
MSB 24488	*Toxostoma curvirostre*	29.99	-103.56
MSB 24489	*Toxostoma curvirostre*	29.99	-103.56
MSB 24616	*Toxostoma curvirostre*	29.99	-103.56
MSB 21019	*Toxostoma curvirostre*	30.27	-103.47
UWBM 95955	*Toxostoma curvirostre*	31.72	-110.78
UWBM 95956	*Toxostoma curvirostre*	31.62	-110.78
UWBM 95957	*Toxostoma curvirostre*	31.62	-110.78
UWBM 90204	*Toxostoma curvirostre*	31.94	-109.72
UWBM 77610	*Toxostoma curvirostre*	32.63	-105.06
AMNH J-18	*Vireo bellii*	32.33	-112.79
AMNH LJM-138	*Vireo bellii*	32.89	-109.50
AMNH KLP-26	*Vireo bellii*	32.91	-109.49
AMNH KLP-44	*Vireo bellii*	32.91	-109.49
AMNH LJM-175	*Vireo bellii*	32.91	-109.49
AMNH J-127	*Vireo bellii*	30.99	-104.87
AMNH DOT-24759	*Vireo bellii*	29.56	-103.81
AMNH DOT-24762	*Vireo bellii*	29.56	-103.81
AMNH DOT-24763	*Vireo bellii*	29.56	-103.81
LSUMZ 3912	*Vireo bellii*	34.80	-116.10
TCWC 24311	*Vireo bellii*	30.55	-104.67
TCWC 24288	*Vireo bellii*	30.55	-104.66
TCWC 24506	*Vireo bellii*	30.06	-103.50
TCWC 24507	*Vireo bellii*	30.06	-103.50
TCWC 16642	*Vireo bellii*	30.14	-103.24
TCWC 24033	*Vireo bellii*	29.58	-102.93
UWBM 77850	*Vireo bellii*	32.87	-109.20
UWBM 77855	*Vireo bellii*	32.87	-109.20