Salvage shortcomings? Comparing the geographic and taxonomic representation between salvaged and actively collected museum specimens in the state of California.

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Warning: package 'kableExtra' was built under R version 4.1.2

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Running headline: Salvaged vs collected specimens

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Introduction

Acting as repositories of the Earth's past and present biodiversity, natural history collections are vital sources of primary biological material (Winker et al. 2010). Preserving records of temporal and spatial trends in said biodiversity, collections have been (and continue to be) employed in a variety of studies across evolutionary biology, pathology, and ecotoxicology, among other disciplines (Winker et al. 2010). Further, collections are vital for understanding how species and populations change over time, patterns that lay the foundation for conservation practices Schmitt et al. (2019).

However, to maintain such records of past and present of biological diversity, constant addition to collections is necessary. Without constant additions, the time series of specimens - essential to documenting trends (see above) - would be interrupted, limiting the collection's usefulness to present and future generations of researchers (Hromada et al. 2015). Unfortunately, with many museums abstaining from this practice altogether (Sweet 2010). This is primarily due to the growing public - and even professional resistance - to traditional active collecting (i.e., intentionally killing birds with the intent of placement in a natural history collection)Russo et al. (2017) . Though for the most part based on misinformation and a lack of knowledge on the importance and impact of collecting, such resistance has nevertheless hampered attempts by museums to obtain collecting permits (Sweet 2010). Consequently, many museums have turned to other methods of acquiring new specimens, including salvage.

Salvaged specimens, broadly defined as any specimen that was not intentionally killed for placement within a museum collection (Sweet 2010), come in many forms, including victims of roadkill, euthanizations at wildlife hospitals, and building collisions, among others (Sweet 2010). Yet, salvaged specimens are likely an inadequate replacement for active collecting. Many salvaged specimens arrive to the museum in poor condition (limiting the amount of information, such as intact tissue samples and complete skeletons, that can be obtained) and/or without any geographic information (key for any study requiring information on the specimen's geographic context when collected) (Sweet 2010). Further, unintentional taxonomic and geographic biases may be introduced. Most salvaged specimens are gathered from areas that are open and easily accessible to humans (Sweet 2010). Areas and habitats that are harder to access (e.g., areas away

from roads, rivers, etc.) may thus be underrepresented in collections Dias Tarli et al. (2018). Further, many species falling victim to primary salvage sources, such as building collisions, are primarily migrants, potentially leading to an overrepresentation of such species in collections and an underrepresentation of more sedentary species and populations (Shultz et al. 2021).

Despite these concerns, no study has assessed the geographic or taxonomic extent covered by salvaged specimens. Here, I conduct a case study on Californian birds within the collection of University of California (UC) Berkley's Museum of Vertebrate Zoology, assessing the geographic (county) and taxonomic (genera) coverage of salvaged versus actively collected museum specimens.

Methods

Data

All data was obtained from the Arctos database (GIVE SOURCE), for all bird specimens collected within the last 20 years in the state of California that are currently housed at the Museum of Vertebrate Zoology, UC Berkley. Data was cleaned, wrangled, visualized, and analyzed in R (4.0.2) (see below). Both raw and final datasets are available from github repository (https://github.com/slrutledge27/BIOL7800). See below for R workflow.

##R Workflow: Reading, Cleaning, Wrangling, Visualizing Data

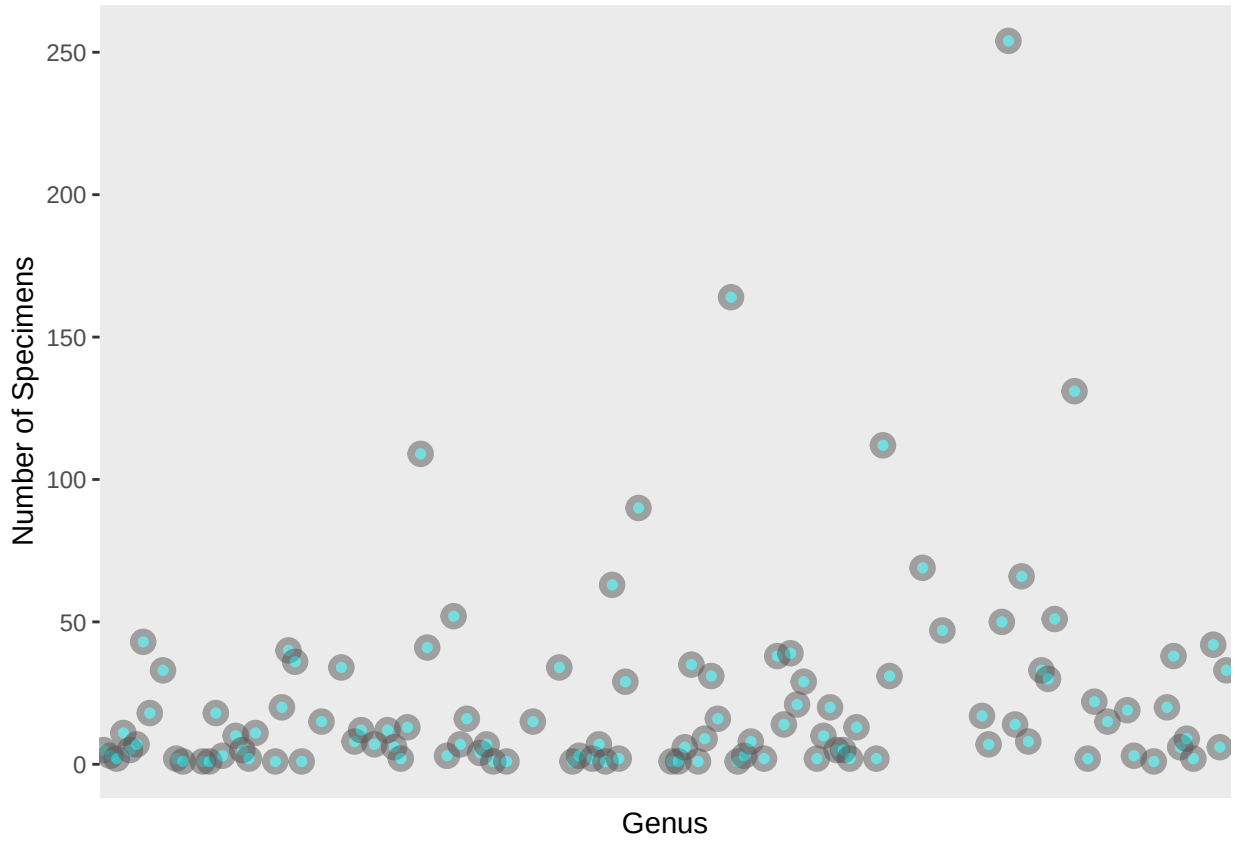
```
## -- Attaching packages --------------------------------------------- tidyverse 1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.5     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.0.2     v forcats 0.5.1

## -- Conflicts ------------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter()     masks stats::filter()
```

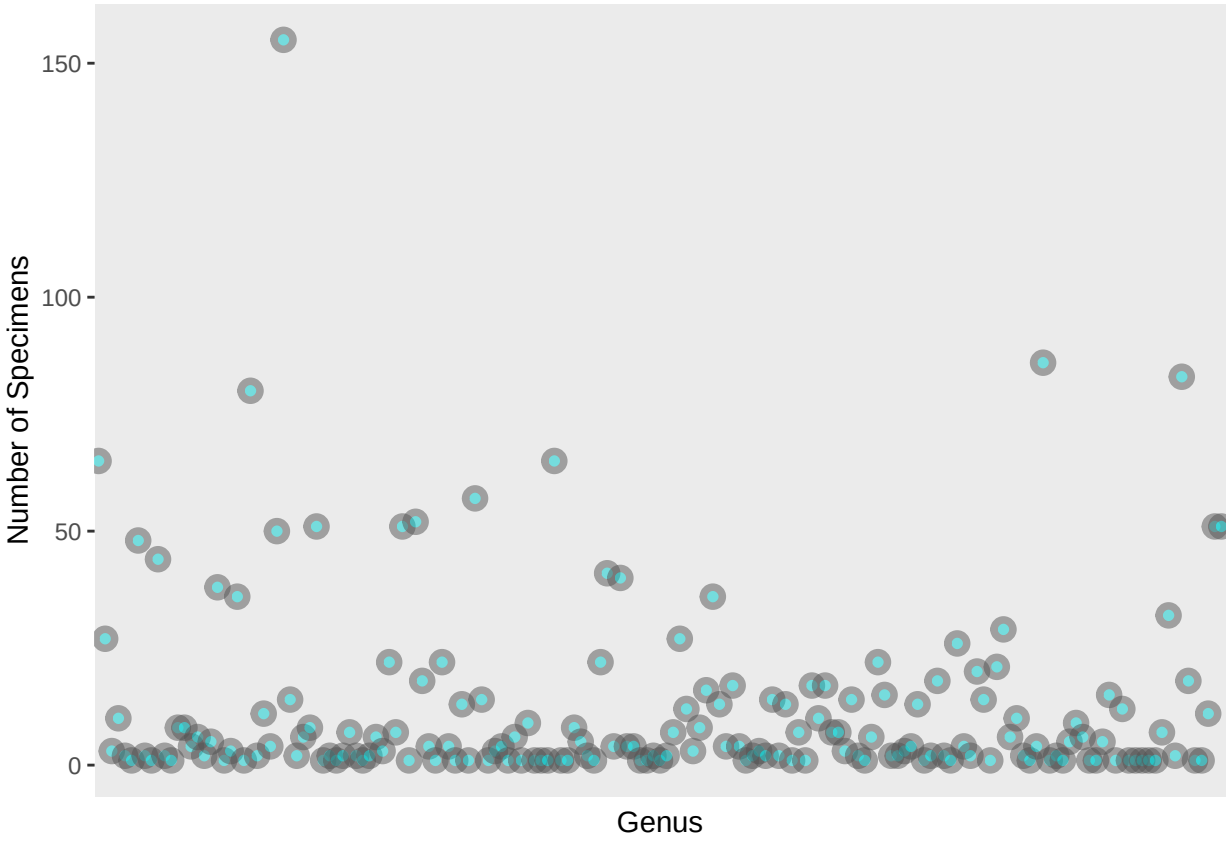
x dplyr::group_rows() masks kableExtra::group_rows()
x dplyr::lag()   masks stats::lag()

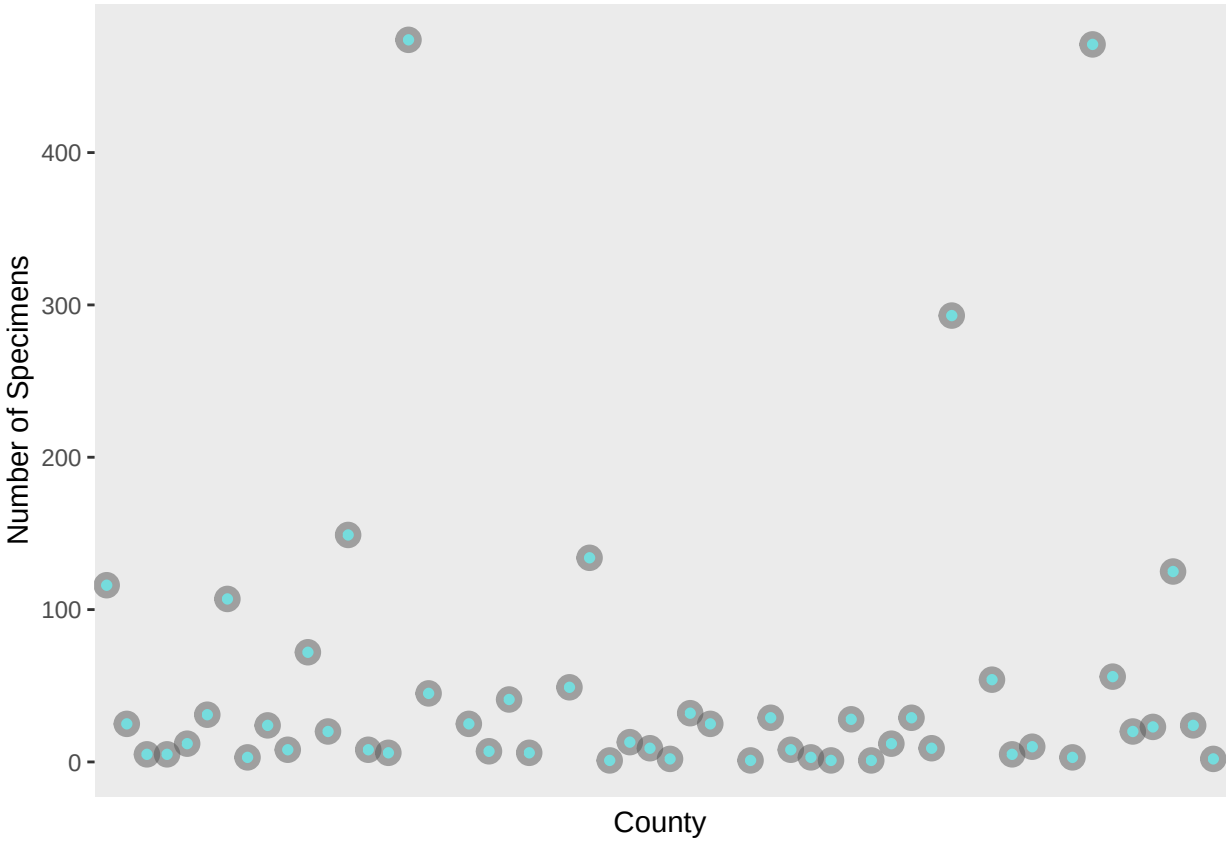
Rows: 6506 Columns: 18

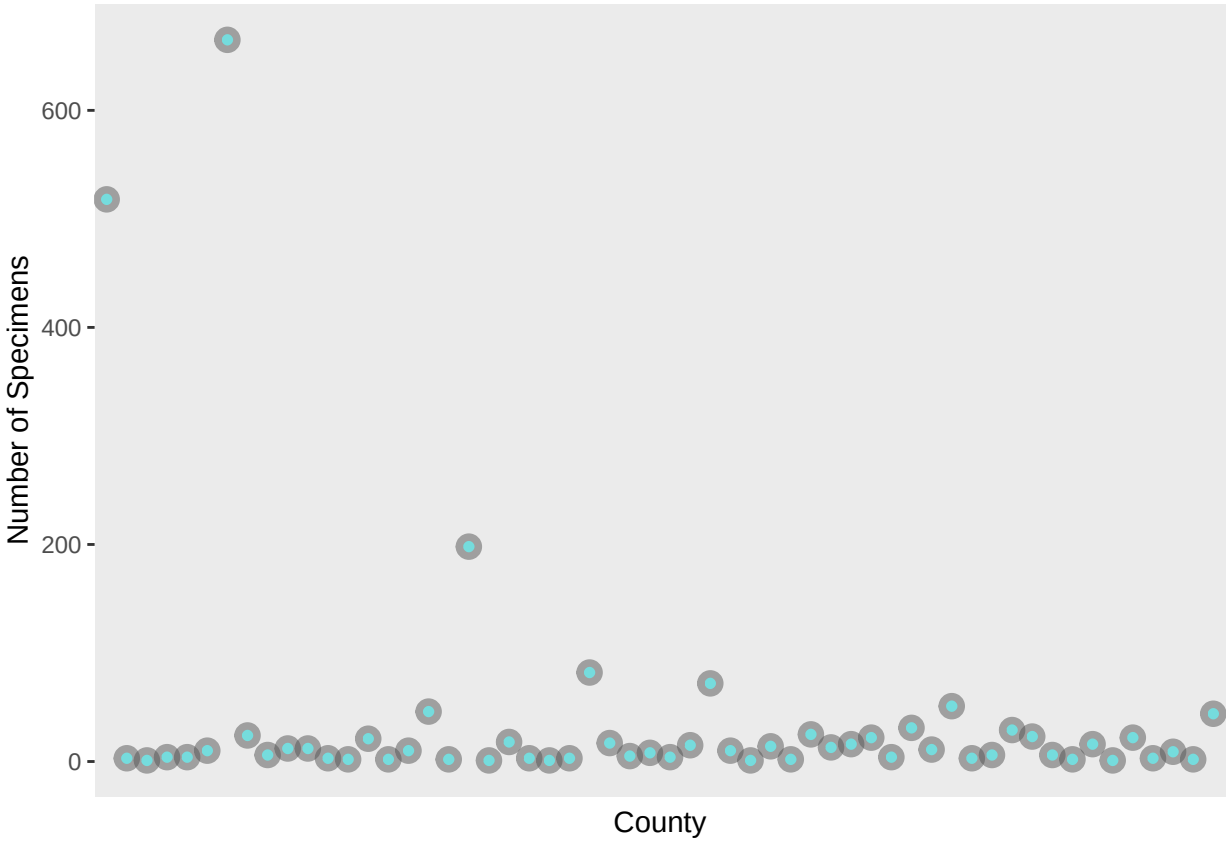
-- Column specification --
Delimiter: ","
chr (15): collecting_method, guid, othercatalognumbers, accn_number, scientific_name...
dbl (3): dec_lat, dec_long, coordinateuncertaintyinmeters

##
i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.




150
100
50
0
Number of Specimens
Genus


Number of Specimens
400
300
200
100
0
County



R Workflow: Data Analysis

Two Chi Squares Goodness of Fit were conducted, one to determine whether the genera represented by salvaged specimens was statistically different from those represented by actively collected specimens, a second to compare the same for county representation. The percentages calculated for actively collected and salvaged specimens were inputted as expected and observed values, respectively.

```
##
##  Pearson's Chi-squared test
##
## data:  observed and expected
## X-squared = 779, df = 650, p-value = 4e-04

##
```

```
##  Pearson's Chi-squared test
##
## data:  observed and expected
## X-squared = 545, df = 480, p-value = 0.02
```

Results

Salvaged and actively collected specimens represented the following proportions of specimens contained within the final dataset:

```
##
##  active salvage
##   0.558   0.442
```

For genera: 171 and 137 were represented for salvaged and actively collected specimens, respectively 1. For county: 56 and 53 were represented 2 for salvaged and actively collected specimens, respectively. See **??** and **??** for genera and county counts, respectively, for salvaged and actively collected specimens. Chi squares were significant for both genera:

```
##
##  Pearson's Chi-squared test
##
## data:  observed and expected
## X-squared = 779, df = 650, p-value = 4e-04
```

and county:

```
##
##  Pearson's Chi-squared test
##
## data:  observed and expected
## X-squared = 545, df = 480, p-value = 0.02
```

,with salvaged specimens having significantly different proportions represented for genera and county than actively collected specimens.

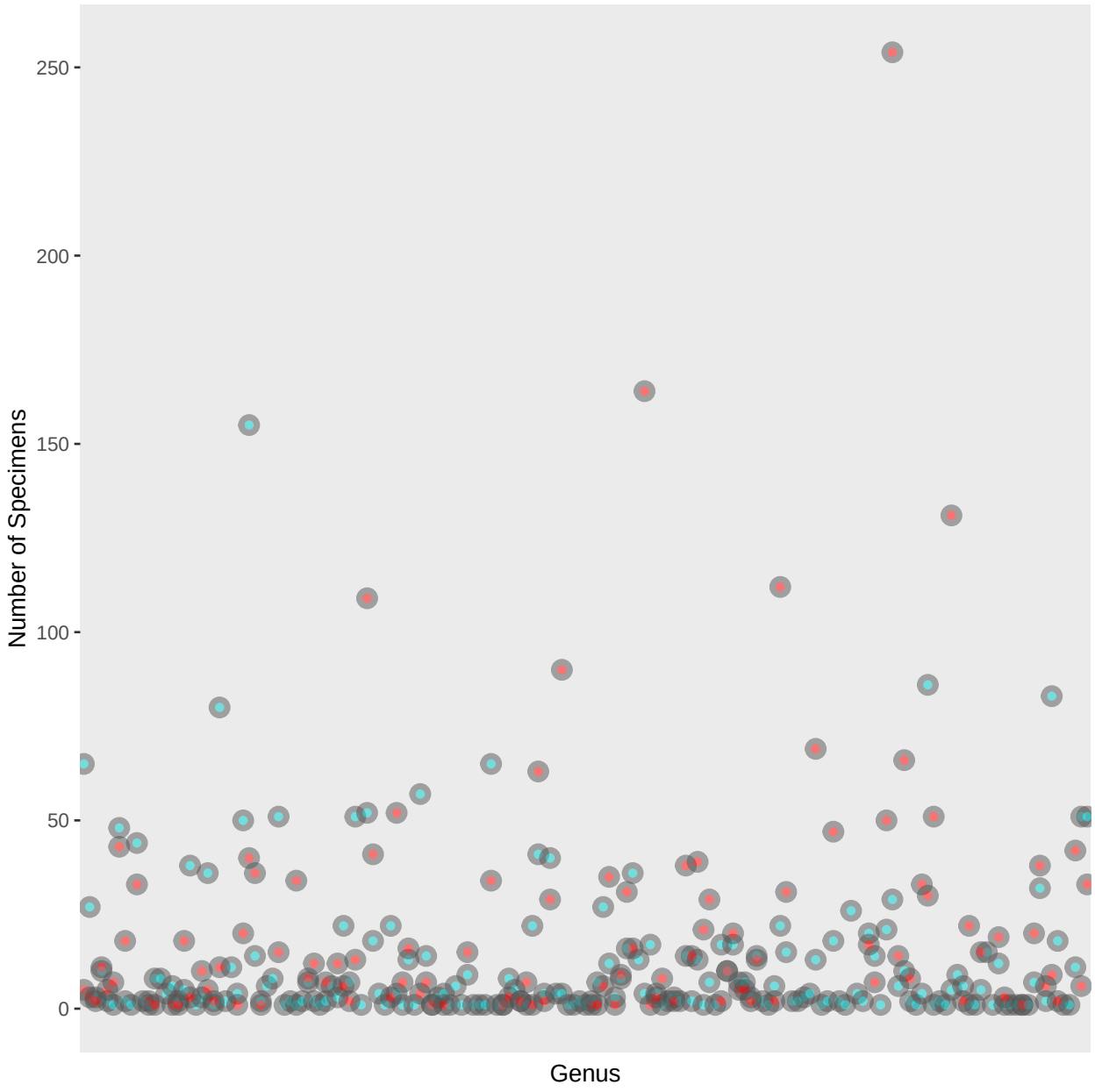


Figure 1. Genera represented by salvaged (blue dots) and actively collected (red dots) specimens.

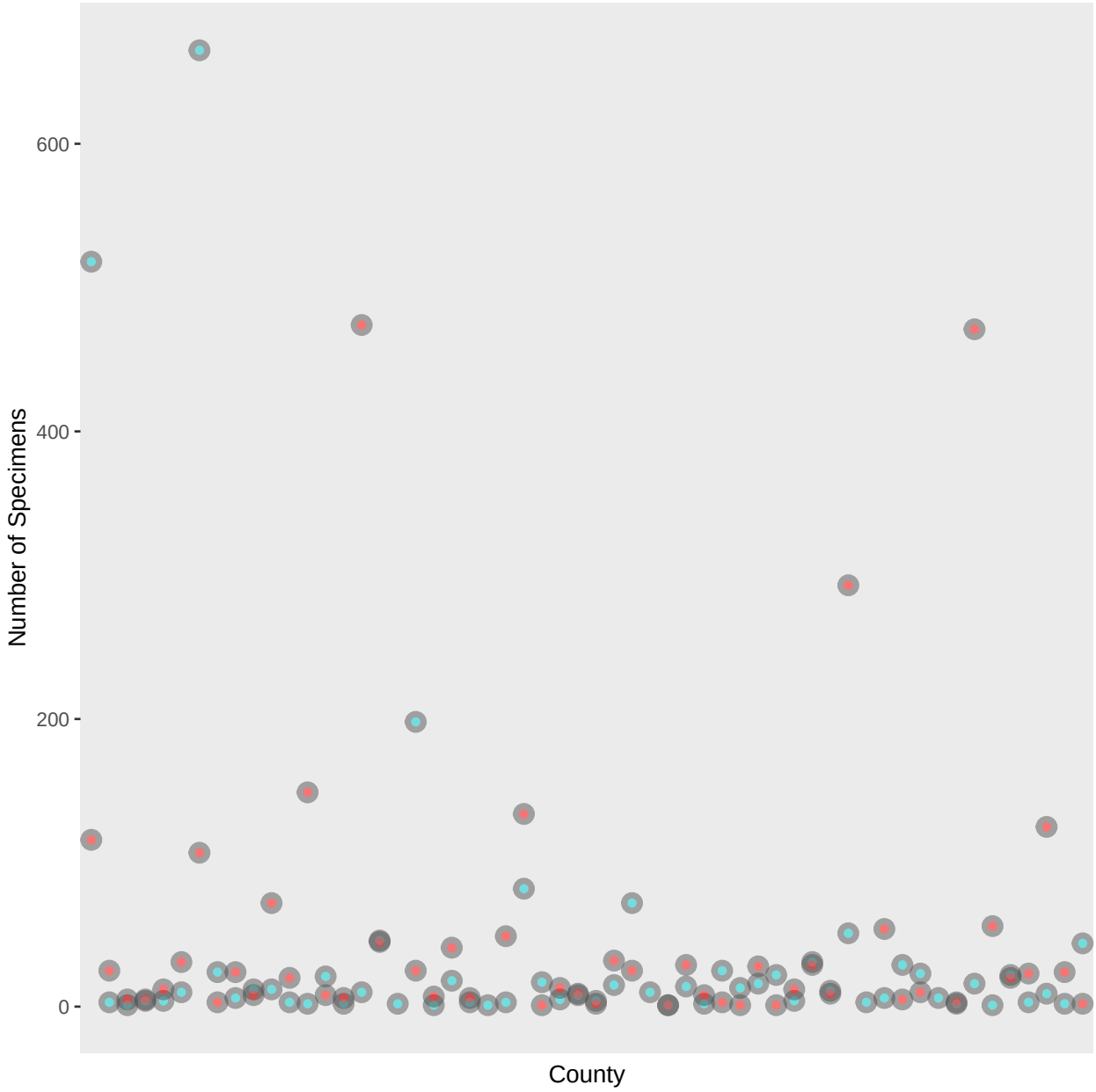


Figure 2. Counties represented by salvaged (blue dots) and actively collected (red dots) specimens

Figures

Tables

##

active salvage

0.558 0.442

Discussion

‘ The taxonomic and geographic representation of avian specimens housed within the Museum of Vertebrate Zoology was significantly different between salvage and actively collected specimens. Thus, as speculated, the taxonomic and geographic representation provided by salvaged versus actively collected specimens are not the same. However, salvaged specimens unexpectedly had greater representation in more counties and genera than actively collected specimens, though several counties and genera represented by salvaged specimens were not represented by active collecting (and vice versa).

Taxonomic coverage for salvaged specimens was surprisingly greater for salvage than actively collected specimens; however, this finding is likely due the inclusion of specimens sourced from Californian zoos, aviaries, and other captive populations. Such sources often contain species that are non-local to the area (i.e., exotic) (Sweet 2010).

Geographic coverage was also lower for actively collected than salvaged specimens. One reason for this may be the difficulty involved in obtaining permits to actively collect versus salvage: due to public/professional resistance towards active collecting, it may be harder – or even impossible – to obtain permission to obtain birds in certain areas through traditional collecting methods (e.g., shotgun, mistnet) [Minteer et al. (2014), Remsen (1995) . Further, for salvaged specimens, the top five counties where specimens were obtained are within the top 20 most populated in California; as such, such locales are likely more developed, with more structures increasing the risk of collision deaths/window strikes in birds, leading to greater opportunities for salvage [Klem Jr (2014), Rioux et al. (2013) , . Meanwhile, top counties for active collection are among the least populated in California; additionally, they are underrepresented by salvaged specimens (i.e., many counties in which actively collected specimens are obtained contain no or few salvaged samples). This again may reflect the difficulty of obtaining salvaged specimens from locales that are less frequented (and therefore less likely for a dead bird to be found before it is scavenged), as well as less developed (resulting in fewer deaths by collision, leading to a

dependence on actively collected specimens to represent these regions) Rioux et al. (2013).

While insightful, this comparison of salvage and active collected specimens remains very coarse. For instance, regarding geographic coverage, it would be interesting to see which specific localities within counties salvaged versus actively collected specimens are being collected; it is likely that biases may appear, with specific areas having a higher number of citizens involved in salvaging specimens. Additionally, as mentioned above, salvaged specimens are more likely to be sourced from around a few highly developed areas, while actively collected specimens may show a more general distribution (potentially providing a more accurate idea of presence/absence data of species within the county). An examination of each county based on its population and/or level of structural development would be insightful for ascertaining any geographic biases associated with salvaged specimens, a crucial step for accounting for said biases in future studies (Dias Tarli et al. 2018). Finally, future comparisons should account for specimens obtained from aviary/zoos when calculating taxonomic representation, to ascertain whether salvaged specimens do in fact represent a greater taxonomic coverage than actively collected specimens, or whether such representation is artificially inflated by the inclusion of exotic taxa.

Conclusion

Salvaged and actively collected specimens provide different pictures of the biodiversity within the state of California, for both taxonomy (genus level) and geography (county level). As such, adding to natural history collections through salvage will not replace actively collecting specimens, nor can actively collected specimens be expected to encompass the representation provided by salvaged records. Consequently, both salvage and active collecting are needed for the most comprehensive representation of avian biodiversity in museum collections.

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