

# A standard taxonomic effort (STE) for terrestrial arthropods collected from dry streams in California and Arizona



Raphael D. Mazor



SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

Technical Report 1343



# **A standardized taxonomic effort (STE) for terrestrial arthropods collected from dry streams in California and Arizona**

Raphael D. Mazor

*Southern California Coastal Water Research Project, Costa Mesa, CA*

**November 2023**

Technical Report 1343

## **ACKNOWLEDGMENTS**

Brady Richards, Dan Pickard, Tracy Morman, and John Sandberg of the California Department of Fish and Wildlife's Aquatic Bioassessment Lab provided invaluable technical guidance in developing this document. Funding was provided by the Surface Water Ambient Monitoring Program and the California Regional Water Quality Control Board—San Diego region. Initial work on this STE was started by John Olson, Andrew Aguilar, and Adrian Gonzalez at the California State University at Monterey Bay. Susana Theroux, Rachel Darling, and Garrett Keating (SCCWRP) assisted with data analysis. Marco Sigala (Moss Landing Marine Labs), Candice Levesque (California State Water Resources Control Board), and Toni Marshall (California State Water Resources Control Board) assisted with data management.

# TABLE OF CONTENTS

|   |    |
|---|----|
| Acknowledgments.....                                    | i  |
| Table of Contents .....                                 | ii |
| Introduction.....                                       | 4  |
| Development of the Standard Taxonomic Effort .....      | 5  |
| Life Stage Terminology .....                            | 5  |
| The Standard Taxonomic Effort (STE).....                | 5  |
| Aquatic taxa .....                                      | 8  |
| Excluded taxa.....                                      | 8  |
| Part one: Non-insects.....                              | 8  |
| Isopoda (Sowbugs, pillbugs, roly-polies).....           | 8  |
| Amphipods (Scuds) .....                                 | 9  |
| Chilopoda (Centipedes) .....                            | 10 |
| Diplopoda (Millipedes) .....                            | 10 |
| Araneae (Spiders) .....                                 | 10 |
| Scorpiones (Scorpions) .....                            | 14 |
| Pseudoscorpiones (Pseudoscorpions) .....                | 15 |
| Acari (Mites) .....                                     | 15 |
| Solifugae (Sun spiders, camel spiders) .....            | 15 |
| Opiliones (Harvestmen, daddy longlegs) .....            | 16 |
| Collembola (springtails) .....                          | 16 |
| Diplura and Protura (other non-insect hexapods) .....   | 17 |
| Part two: Insects.....                                  | 18 |
| Microcoryphia (Bristletails).....                       | 18 |
| Zygentoma (Silverfish).....                             | 18 |
| Dermaptera (Earwigs) .....                              | 19 |
| Orthoptera (Crickets, grasshoppers, and katydids) ..... | 20 |
| Embiidina (Webspinners) .....                           | 21 |
| Mantodea (Mantises) .....                               | 21 |
| Hemiptera (True bugs) .....                             | 22 |
| Raphidioptera (Snakeflies) .....                        | 29 |
| Neuroptera (Lacewings) .....                            | 29 |

|   |    |
|---|----|
| Coleoptera (Beetles).....   | 30 |
| Hymenoptera: Non-formicidae (Bees, velvet ants, wasps) .....  | 34 |
| Hymenoptera: Formicidae (Ants).....   | 34 |
| Other insects .....   | 39 |
| Cited literature .....  | 40 |
| Appendix: Technical needs for a standardized taxonomic effort for arthropods in California and Arizona dry streams and rivers ..... | 43 |
| Identify or generate more general entomological identification resources.....   | 43 |
| Spiders .....   | 43 |
| Beetles .....   | 44 |
| Ants .....  | 44 |
| Other groups.....   | 45 |
| Additional sampling .....   | 45 |
| Develop keys for select groups .....  | 46 |
| Identify morphospecies .....  | 46 |
| Develop molecular tools.....  | 46 |

# INTRODUCTION

The Aquatic Bioassessment Lab (ABL) of the California Department of Fish and Wildlife, the Southern California Coastal Water Research Project (SCCWRP), and the Watershed Environments and Ecology (WEE) Lab at California State University, Monterey Bay developed standardized levels for the taxonomic identification for arthropods associated with non-perennial river and streams in support of bioassessment of these systems. This document defines the standard levels of taxonomic effort (STE) for analyzing terrestrial arthropod samples collected as part of assessing ecological assessments during the dry phase of non-perennial rivers and streams using methods described in Robinson et al. (2018) and will provide sufficient taxonomic resolution for use with bioassessment indices in development.

This STE is based on our current understanding of dry-stream arthropod taxonomy, and this document was prepared following sections in Rogers and Richards (2006), as well as Richards and Rogers (2011). This list includes taxa found in dry phase non-perennial rivers and streams in southern California, and reflects the level of resolution a well-trained taxonomist can produce given sufficient time and resources. This document is a compilation and distillation of data gleaned from the peer-reviewed literature and the Integrated Taxonomic Information System (ITIS) Report database. Specialized references are suggested for some taxa; however, this document is not a procedural guideline, but rather a list of defined, reproducible endpoints.

This STE list should not be interpreted as a comprehensive list of dry-stream arthropod fauna of these regions, and many species (both described and undescribed) are likely to be found with additional sampling. This STE list includes the arthropod taxa encountered in bioassessment samples as of the date of this document, together with literature records from published taxonomic literature. The higher-level taxa in this list (Phylum through Order) are organized hierarchically to reflect phylogenetic relationships, while Family through Species are listed alphabetically. The higher taxonomy of the Arthropoda is a subject of continued scientific investigation and re-evaluation. Therefore, this STE List will be adjusted as new taxonomic information is found.

Any suggestions for modifications of this list should comply with the STE Rules, and be sent to the attention of Raphael Mazor, Southern California Water Research Project ([raphaelm@sccwrp.org](mailto:raphaelm@sccwrp.org)).

# **DEVELOPMENT OF THE STANDARD TAXONOMIC EFFORT**

The goal of this document is to standardize levels of taxonomic effort used for assessment of ecological health of dry phase non-perennial rivers and streams or similar protocols. For arthropod datasets to be compatible, taxa need to be identified to a common, reproducible level, thus we defined levels of taxonomic resolution (i.e., the standard taxonomic effort or STE) for all labs assessing ecological health of dry phase non-perennial rivers and streams following the protocol by (Robinson et al. 2018).

This document was drafted following sections 2.5.1-2.5.3 and 3.1-3.4.5 of the STE Rules (Rogers and Richards 2006) for the validity of taxonomic names and provisional taxa, their use and reporting in bioassessment datasets. The STE Rules document also outlines the procedures and criteria for subsequent revisions of the STE list.

References for taxonomic identification listed in the STE were obtained from the ITIS database.

## **Life Stage Terminology**

Life stage terminology in the STE depends on the life history of the arthropod identified. Life stages are not recorded for non-insect taxa (e.g., Araneae, Psocodea, Scorpiones, and Solifugae). Among insects, larval and adult life stages are recognized for all taxa, whereas pupal life stages are recognized for holometabolous orders (e.g., Coleoptera, Neuroptera, Hymenoptera).

## **THE STANDARD TAXONOMIC EFFORT (STE)**

### **Summary of the STE**

| Taxonomic group | Valid life stages | Standardized taxonomic effort | Notes and recommended literature                                  |
|-----------------|-------------------|-------------------------------|---|
| Isopoda         | X                 | Family, with some to Species. | Shultz (2018). Brusca online key.<br>Most species are introduced. |
| Amphipoda       | X                 | Order (Talitridae to Family)  | Whitfield et al. (2013)   |

| Taxonomic group  | Valid life stages | Standardized taxonomic effort     | Notes and recommended literature  |
|------------------|-------------------|-----------------------------------|---|
| Chilopoda        | X                 | Class (Scutigeridae to Family)    | Whitfield et al. (2013)   |
| Diplopoda        | X                 | Class                             | Shelley (2002), Whitfield et al. (2013)   |
| Araneae          | X                 | Family                            | Ubick et al. (2017)   |
| Scorpiones       | X                 | Order                             | Whitfield et al. (2013)   |
| Pseudoscorpiones | X                 | Order                             | Whitfield et al. (2013)   |
| Acari            | X                 | Subclass                          | Whitfield et al. (2013)   |
| Solifugae        | X                 | Order                             | Whitfield et al. (2013)   |
| Opiliones        | X                 | Order                             | Whitfield et al. (2013)   |
| Collembola       | X                 | Family                            | Bellinger et al. (2003)<br><a href="http://www.collembola.org">www.collembola.org</a> |
| Diplura          | X                 | Order                             | Whitfield et al. (2013)   |
| Protura          | X                 | Order                             | Whitfield et al. (2013)   |
| Microcoryphia    | L/A               | Family                            | Bowser (2012), Whitfield et al. (2013)  |
| Zygentoma        | L/A               | Family                            | Whitfield et al. (2013)   |
| Dermaptera       | L/A               | Genus, with some taken to species | Langston and Powell (1975). Most species are non-native.                              |
| Orthoptera       | L/A               | Family                            | Morris and Gwynne (1978), Whitfield et al. (2013)                                     |
| Embiidina        | L/A               | Order                             | Ross (1957). 3 species in California.   |
| Phasmida         | L/A               | Order                             | Whitfield et al. (2013)   |

| Taxonomic group              | Valid life stages | Standardized taxonomic effort               | Notes and recommended literature                                   |
|------------------------------|-------------------|---|--|
| Mantodea                     | L/A               | Family                                      | Whitfield et al. (2013)  |
| Blattodea                    | L/A               | Family                                      | Whitfield et al. (2013)  |
| Thysanoptera                 | L/A               | Order                                       | Whitfield et al. (2013)  |
| Hemiptera                    | L/A               | Family                                      | Schuh and Weirauch (2020), Whitfield et al. (2013)                 |
| Psocodea                     | L/A               | Order                                       | Whitfield et al. (2013)  |
| Raphidioptera                | L/A               | Family                                      | Whitfield et al. (2013) for adults, Stehr (1991) for larvae        |
| Neuroptera                   | L/A               | Family                                      | Whitfield et al. (2013) for adults, Stehr (1991) for larvae        |
| Coleoptera                   | L/A               | Family, with larvae left at Order           | Arnett and Thomas (2001, 2002) for adults, Stehr (1991) for larvae |
| Hymenoptera (non-Formicidae) | A                 | Order, with Apidae and Mutillidae to Family | Whitfield et al. (2013)<br>Larvae generally not collected          |
| Formicidae                   | A                 | Genus, with some taken to species           | Ward (2005).<br>Larvae generally not collected.                    |
| Lepidoptera                  | L/A               | Order                                       | Whitfield et al. (2013)  |
| Mecoptera                    | A                 | Order                                       | Whitfield et al. (2013)<br>Larvae generally not collected.         |
| Ephemeroptera                | L/A               | Order                                       | Whitfield et al. (2013)  |

| Taxonomic group | Valid life stages | Standardized taxonomic effort | Notes and recommended literature |
|-----------------|-------------------|-------------------------------|----------------------------------|
| Plecoptera      | L/A               | Order                         | Whitfield et al. (2013)          |
| Trichoptera     | L/P/A             | Order                         | Whitfield et al. (2013)          |
| Megaloptera     | L/P/A             | Order                         | Whitfield et al. (2013)          |
| Odonata         | L/A               | Order                         | Whitfield et al. (2013)          |
| Diptera         | L/P/A             | Order                         | Whitfield et al. (2013)          |
| Psocodea        | L/A               | Order                         | Whitfield et al. (2013)          |
| Zoraptera       | L/A               | Order                         | Whitfield et al. (2013)          |
| Grylloblatodea  | L/A               | Order                         | Whitfield et al. (2013)          |

## Aquatic taxa

Aquatic taxa may be encountered, typically as adult life stages. These groups are generally left at the Order level (apart from Hemiptera).

## Excluded taxa

Parasitic taxa are excluded from data sets:

- Siphonaptera (fleas)
- Strepsiptera (twisted-wing parasites)

## Part one: Non-insects

### Isopoda (Sowbugs, pillbugs, roly-pollies)

STE: Family, with Armadillidium to species

Twenty-two species in nine families of Oniscidea occur in California. Most species are introduced. Shultz (2018) provides a key to Maryland fauna, which should be adequate for family-level identification in California. The online Oniscidea key (Brusca et al. 2001;

[http://tolweb.org/notes/?note\\_id=4179](http://tolweb.org/notes/?note_id=4179)) is also useful. *Armadillidium* is easy to recognize and separate to species.

#### References:

Brusca, R., V. R. Coelho, and S. Taiti. 2001. A guide to the Coastal Isopods of California. Tree of Life. (Available from: [http://tolweb.org/notes/?note\\_id=3004](http://tolweb.org/notes/?note_id=3004))

Shultz, J. W. 2018. A guide to the identification of the terrestrial Isopoda of Maryland, U.S.A. (Crustacea). ZooKeys 801:207–228.

| Order   | Suborder  | Family          | Genus         | Species                  | Author                    |
|---------|-----------|-----------------|---------------|--------------------------|---------------------------|
| Isopoda |           |                 |               |                          | Latreille 1802            |
| Isopoda | Oniscidea |                 |               |                          |                           |
| Isopoda | Oniscidea | Ligiidae        |               |                          | Leach 1814                |
| Isopoda | Oniscidea | Tylidae         |               |                          | Dana 1852                 |
| Isopoda | Oniscidea | Trichoniscidae  |               |                          | Milne<br>Edwards,<br>1853 |
| Isopoda | Oniscidea | Scyphacidae     |               |                          |                           |
| Isopoda | Oniscidea | Platyarthridae  |               |                          | Vandel 1946               |
| Isopoda | Oniscidea | Armadillidae    |               |                          | Brandt 1831               |
| Isopoda | Oniscidea | Porcellionidae  |               |                          | Brandt 1831               |
| Isopoda | Oniscidea | Armadillidiidae |               |                          | Brandt 1833               |
| Isopoda | Oniscidea | Armadillidiidae | Armadillidium |                          | Brandt 1833               |
| Isopoda | Oniscidea | Armadillidiidae | Armadillidium | Armadillidium<br>vulgare | Latreille 1804            |
| Isopoda | Oniscidea | Philosciidae    |               |                          |                           |

## Amphipods (Scuds)

STE: Talitridae to family; others to order.

Terrestrial amphipods in the family Talitridae (beach hoppers) are typically found in beaches, but aquatic taxa are sometimes encountered in dry riverbed samples.

#### References:

Thorp, J. H., D. C. Rogers, and A. P. Covich (Eds.). 2015. Thorp and Covich's Freshwater invertebrates. Fourth edition. Elsevier/AP, Academic Press is an imprint of Elsevier, Amsterdam; Boston.

| Order     | Family     |
|-----------|------------|
| Amphipoda |            |
| Amphipoda | Talitridae |

## Chilopoda (Centipedes)

STE: Class, with some groups to Family

Centipedes should be left at Class, although house centipedes (Scutigeridae) may be readily identified to Family using Whitfield et al. (2013).

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Class     | Family       | Author     |
|-----------|--------------|------------|
| Chilipoda |              |            |
| Chilipoda | Scutigeridae | Leach 1814 |

## Diplopoda (Millipedes)

STE: Class

Over 200 species and subspecies of millipedes occur in California, representing 24 families and 11 orders (Shelley 2002). All should be left at Class.

References:

Shelley, R. M. 2002. Annotated Checklist Of The Millipedes Of California (Arthropoda: Diplopoda). Monographs of the Western North American Naturalist 1:90–115.

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Class     | Author |
|-----------|--------|
| Diplopoda |        |

## Araneae (Spiders)

STE: Family

Spiders are among the most diverse groups of terrestrial arthropods, with over 1,000 species identified in California in 55 families. Spiders are common in both streambed samples as well as

samples collected from riparian vegetation. Ubick et al. (2017) remains the best source for identifying spider families. A few families are monotypic in North America, and may be taken to genus or species with confidence.

#### References:

Ubick, D., P. Paquin, P. E. Cushing, V. D. Roth, N. Dupérré, and American Arachnological Society (Eds.). 2017. Spiders of North America: An identification manual. 2nd ed. American Arachnological Society, Keene, New Hampshire.

| Family               | Genus             | Species                  | Author       | Notes   |
|----------------------|-------------------|--------------------------|--------------|---|
| <b>Agelenidae</b>    |                   |                          |              |   |
| <b>Amaurobiidae</b>  |                   |                          |              |   |
| <b>Amphinectidae</b> |                   |                          |              | one introduced species in North America: <i>Metaltella simoni</i> (Keyserling); may now be listed under Desidae           |
| Amphinectidae        | <i>Metaltella</i> |                          |              |   |
| Amphinectidae        | <i>Metaltella</i> | <i>Metaltella simoni</i> | (Keyserling) |   |
| Anapidae             |                   |                          |              |   |
| Anyphaenidae         |                   |                          |              |   |
| Araneidae            |                   |                          |              |   |
| Caponiidae           |                   |                          |              |   |
| Cheiracanthiidae     |                   |                          |              | new name for Eutichuridae; records on BugGuide not specifically mentioned as being in CA; many records on BugGuide for CA |
| Clubionidae          |                   |                          |              |   |
| Corinnidae           |                   |                          |              |   |

| Family                | Genus               | Species                  | Author | Notes   |
|-----------------------|---------------------|--------------------------|--------|---|
| <b>Ctinidae</b>       |                     |                          |        |   |
| <b>Cybaeidae</b>      |                     |                          |        |   |
| <b>Desidae</b>        |                     |                          |        | single introduced species:<br><i>Badumna longinqua</i> (Koch)                                   |
| <b>Desidae</b>        | <i>Badumna</i>      |                          |        |   |
| <b>Desidae</b>        | <i>Badumna</i>      | <i>Badumna longinqua</i> | (Loch) |   |
| <b>Dictynidae</b>     |                     |                          |        |   |
| <b>Diguetidae</b>     |                     |                          |        | one genus in North America:<br><i>Diguetia</i>  |
| <b>Diguetidae</b>     | <i>Diguetia</i>     |                          |        |   |
| <b>Dysderidae</b>     |                     |                          |        | cosmopolitan; one species in North America:<br><i>Dysdera crocata</i> Koch; records on BugGuide |
| <b>Dysderidae</b>     | <i>Dysdera</i>      |                          |        |   |
| <b>Dysderidae</b>     | <i>Dysdera</i>      | <i>Dysdera crocata</i>   | Koch   |   |
| <b>Filistatidae</b>   |                     |                          |        |   |
| <b>Gnaphosidae</b>    |                     |                          |        |   |
| <b>Hahnidae</b>       |                     |                          |        |   |
| <b>Homalonychidae</b> |                     |                          |        | one genus in North America:<br><i>Homalonychus</i>  |
| <b>Homalonychidae</b> | <i>Homalonychus</i> |                          |        |   |
| <b>Hypochilidae</b>   |                     |                          |        | <i>Hypochilus</i> is only genus in NA; three species known from CA                              |

| Family         | Genus             | Species | Author | Notes  |
|----------------|-------------------|---------|--------|--|
| Hypochilidae   | <i>Hypochilus</i> |         |        |  |
| Leptonetidae   |                   |         |        |  |
| Linyphiidae    |                   |         |        |  |
| Liocranidae    |                   |         |        |  |
| Lycosidae      |                   |         |        |  |
| Mimetidae      |                   |         |        |  |
| Miturgidae     |                   |         |        |  |
| Mismenidae     |                   |         |        |  |
| Nesticidae     |                   |         |        | probably just found in caves                               |
| Oecobiidae     |                   |         |        |  |
| Oonopidae      |                   |         |        |  |
| Oxyopidae      |                   |         |        |  |
| Philodromidae  |                   |         |        | records for CA on BugGuide                                 |
| Pholcidae      |                   |         |        | records for CA on BugGuide                                 |
| Phrurolithidae |                   |         |        |  |
| Pimoidae       |                   |         |        | one genus in North America: <i>Pimoa</i>                   |
| Pimoidae       | <i>Pimoa</i>      |         |        |  |
| Pisauridae     |                   |         |        |  |
| Plectreuridae  |                   |         |        |  |
| Prodidomidae   |                   |         |        |  |
| Salticidae     |                   |         |        |  |
| Scytodidae     |                   |         |        | currently only one genus in North America: <i>Scytodes</i> |
| Scytodidae     | <i>Scytodes</i>   |         |        |  |
| Segestriidae   |                   |         |        |  |
| Selenopidae    |                   |         |        | one genus in North America: <i>Selenops</i>                |
| Selenopidae    | <i>Selenops</i>   |         |        |  |

| Family                  | Genus               | Species                          | Author          | Notes  |
|-------------------------|---------------------|----------------------------------|-----------------|--|
| <b>Sicariidae</b>       |                     |                                  |                 | one genus in North America:<br><i>Loxosceles</i>   |
| <b>Sicariidae</b>       | <i>Loxosceles</i>   |                                  |                 |  |
| <b>Sparassidae</b>      |                     |                                  |                 |  |
| <b>Telemidae</b>        |                     |                                  |                 | one genus in North America:<br><i>Usofila</i>  |
| <b>Telemidae</b>        | <i>Usofila</i>      |                                  |                 |  |
| <b>Tetragnathidae</b>   |                     |                                  |                 |  |
| <b>Theridiidae</b>      |                     |                                  |                 |  |
| <b>Thomisidae</b>       |                     |                                  |                 |  |
| <b>Titanoecidae</b>     |                     |                                  |                 | one genus in North America:<br><i>Titanoeca</i>  |
| <b>Titanoecidae</b>     | <i>Titanoeca</i>    |                                  |                 |  |
| <b>Trachelidae</b>      |                     |                                  |                 |  |
| <b>Trogloraptoridae</b> |                     |                                  |                 | single species known;<br><i>Trogloraptor marchingtoni</i><br>Griswold et al; nCAL and OR |
| <b>Trogloraptoridae</b> | <i>Trogloraptor</i> |                                  |                 |  |
| <b>Trogloraptoridae</b> | <i>Trogloraptor</i> | <i>Trogloraptor marchingtoni</i> | Griswold et al. |  |
| <b>Uloboridae</b>       |                     |                                  |                 | records for CA on BugGuide   |
| <b>Zodariidae</b>       |                     |                                  |                 |  |
| <b>Zoropsidae</b>       |                     |                                  |                 |  |

## Scorpiones (Scorpions)

STE: Order

Four families are known from California (i.e., Buthidae, Iuridae, Superstitioniidae, and Vaejovidae), but separating these can be difficult even for experts.

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Order      | Author |
|------------|--------|
| Scorpiones |        |

## Pseudoscorpiones (Pseudoscorpions)

STE: Order

Five families are found in California (Atemnidae, Cheridiidae, Chthoniidae, Garypidae, and Neobisiidae), but these should be left at the Order level.

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Order            | Author       |
|------------------|--------------|
| Pseudoscorpiones | De Geer 1778 |

## Acari (Mites)

STE: Subclass

Although aquatic mites are taken to genus or species in benthic samples (Richards and Rogers 2011), terrestrial mites should be left at Order.

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Subclass | Author |
|----------|--------|
| Acari    |        |

## Solifugae (Sun spiders, camel spiders)

STE: Order

This order is currently under revision.

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Order     | Author          |
|-----------|-----------------|
| Solifugae | Sundevall, 1833 |

## Opiliones (Harvestmen, daddy longlegs)

STE: Order

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Order     | Author          |
|-----------|-----------------|
| Opiliones | Sundevall, 1833 |

## Collembola (springtails)

STE: Family

Collembola should be identified to family using the keys in the Collembola of the World website (Bellinger et al. 2003, <http://www.collembola.org>).

References:

Bellinger, P. F., K. A. Christiansen, and F. Janssens. 2003. Checklist of Collembola of the World. (Available from: <http://www.collembola.org>)

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Class      | Order          | Family          | Notes                |
|------------|----------------|-----------------|----------------------|
| Collembola | Neelipleona    |                 |                      |
| Collembola | Neelipleona    | Neelidae        |                      |
| Collembola | Symplypleona   |                 |                      |
| Collembola | Symplypleona   | Mackenziellidae | May not occur in US? |
| Collembola | Symplypleona   | Sminthurididae  |                      |
| Collembola | Appendiciphora |                 |                      |

| Class      | Order            | Family             | Notes                        |
|------------|------------------|--------------------|------------------------------|
| Collembola | Appendiciphora   | Katiannidae        |                              |
| Collembola | Appendiciphora   | Spinothecidae      | May not occur in western US? |
| Collembola | Appendiciphora   | Arrhopalitidae     |                              |
| Collembola | Appendiciphora   | Collophoridae      |                              |
| Collembola | Appendiciphora   | Sturmiidae         |                              |
| Collembola | Appendiciphora   | Dicyrtomidae       |                              |
| Collembola | Appendiciphora   | Bourletiellidae    | Found in CA samples          |
| Collembola | Appendiciphora   | Sminthuridae       |                              |
| Collembola | Poduromorpha     |                    |                              |
| Collembola | Poduromorpha     | Onychiuridae       |                              |
| Collembola | Poduromorpha     | Tulbergiidae       |                              |
| Collembola | Poduromorpha     | Isotogastruridae   |                              |
| Collembola | Poduromorpha     | Pachytullbergiidae |                              |
| Collembola | Poduromorpha     | Odontellidae       |                              |
| Collembola | Poduromorpha     | Hypogastruridae    |                              |
| Collembola | Poduromorpha     | Paleotullbergiidae |                              |
| Collembola | Poduromorpha     | Poduridae          |                              |
| Collembola | Poduromorpha     | Neanuridae         |                              |
| Collembola | Poduromorpha     | Brachystomellidae  |                              |
| Collembola | Entomobryomorpha |                    |                              |
| Collembola | Entomobryomorpha | Oncopoduridae      |                              |
| Collembola | Entomobryomorpha | Tomoceridae        |                              |
| Collembola | Entomobryomorpha | Actaletidae        |                              |
| Collembola | Entomobryomorpha | Isotomidae         | Found in CA samples          |
| Collembola | Entomobryomorpha | Orchesellidae      |                              |
| Collembola | Entomobryomorpha | Paronellidae       |                              |
| Collembola | Entomobryomorpha | Entomobryidae      | Found in CA samples          |
| Collembola | Entomobryomorpha | Coenaletidae       |                              |

## Diplura and Protura (other non-insect hexapods)

STE: Class

Although they are unlikely to be found in pitfall traps or riparian vegetation, any proturans or diplurans encountered should be left at Class.

## References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Class   | Author         |
|---------|----------------|
| Protura | Silvestri 1907 |
| Diplura | Börner 1904    |

## Part two: Insects

### Microcoryphia (Bristletails)

STE: Family

Microcoryphia are represented by two families in California, and they are easy to separate using Whitfield et al. (2013). Mature specimens may also be identified using the unpublished key by Bowser (2012).

## References:

Bowser, M. L. 2012. Key and checklist of the bristletails (Microcoryphia) of America north of Mexico. (Available from: [https://www.researchgate.net/profile/Matthew-Bowser-2/publication/341030994\\_Key\\_and\\_checklist\\_of\\_the\\_bristletails\\_Microcoryphia\\_of\\_America\\_north\\_of\\_Mexico/](https://www.researchgate.net/profile/Matthew-Bowser-2/publication/341030994_Key_and_checklist_of_the_bristletails_Microcoryphia_of_America_north_of_Mexico/))

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Order         | Family         | Author        |
|---------------|----------------|---------------|
| Microcoryphia |                | Börner 1904   |
| Microcoryphia | Machilidae     |               |
| Microcoryphia | Meinertellidae | Verhoeff 1910 |

### Zygentoma (Silverfish)

STE: Family

## References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

| Order     | Family           | Author      |
|-----------|------------------|-------------|
| Zygentoma |                  | Börner 1904 |
| Zygentoma | Lepismatidae     |             |
| Zygentoma | Maindroniidae    |             |
| Zygentoma | Nicoletiidae     |             |
| Zygentoma | Protrinemuridae  |             |
| Zygentoma | Tricholepidiidae |             |

## Dermoptera (Earwigs)

STE: Genus

Langston and Powell (1975) is the best source to identify California's earwig taxa. Seven species are established in California, only one of which is native (*Spongovostox apicedentatus*, found in deserts).

References:

Langston, R. L., and J. A. Powell. 1975. The earwigs of California (order Dermaptera). University of California Press, Berkeley.

| Order      | Family          | Subfamily      | Genus        | Species                 | Notes   |
|------------|-----------------|----------------|--------------|-------------------------|---|
| Dermoptera |                 |                |              |                         |   |
| Dermoptera | Carcinophoridae |                |              |                         |   |
| Dermoptera | Carcinophoridae |                | Anisolabis   |                         |   |
| Dermoptera | Carcinophoridae |                | Anisolabis   | Anisolabis maritima     | Non-native, but native range poorly understood. |
| Dermoptera | Carcinophoridae |                | Euborellia   |                         |   |
| Dermoptera | Carcinophoridae |                | Euborellia   | Euborellia annulipes    | Non-native.                                     |
| Dermoptera | Carcinophoridae |                | Euborellia   | Euborellia cincticollis | Non-native.                                     |
| Dermoptera | Labiidae        |                |              |                         |   |
| Dermoptera | Labiidae        | Spongiphoridae |              |                         |   |
| Dermoptera | Labiidae        | Spongiphoridae | Spongovostox |                         |   |
| Dermoptera | Labiidae        | Spongiphoridae | Spongovostox | Spongovostox            | Native species,                                 |

| Order      | Family       | Subfamily | Genus             | Species                      | Notes             |
|------------|--------------|-----------|-------------------|------------------------------|-------------------|
|            |              |           |                   | <i>apicedentatus</i>         | found in deserts. |
| Dermoptera | Labiidae     | Labiinae  |                   |                              |                   |
| Dermoptera | Labiidae     | Labiinae  | <i>Labia</i>      |                              |                   |
| Dermoptera | Labiidae     | Labiinae  | <i>Labia</i>      | <i>Labia minor</i>           | Non-native.       |
| Dermoptera | Labiidae     | Labiinae  | <i>Marava</i>     |                              |                   |
| Dermoptera | Labiidae     | Labiinae  | <i>Marava</i>     | <i>Marava arachidis</i>      | Non-native.       |
| Dermoptera | Labiduridae  |           |                   |                              |                   |
| Dermoptera | Labiduridae  |           | <i>Labidura</i>   |                              |                   |
| Dermoptera | Labiduridae  |           | <i>Labidura</i>   | <i>Labidura riparia</i>      | Non-native.       |
| Dermoptera | Chelisochidæ |           |                   |                              |                   |
| Dermoptera | Chelisochidæ |           | <i>Chelisoche</i> |                              |                   |
| Dermoptera | Chelisochidæ |           | <i>Chelisoche</i> | <i>Chelisoches morio</i>     | Non-native.       |
| Dermoptera | Forficulidae |           |                   |                              |                   |
| Dermoptera | Forficulidae |           | <i>Doru</i>       |                              |                   |
| Dermoptera | Forficulidae |           | <i>Doru</i>       | <i>Doru lineare</i>          | Non-native.       |
| Dermoptera | Forficulidae |           | <i>Forficula</i>  |                              |                   |
| Dermoptera | Forficulidae |           | <i>Forficula</i>  | <i>Forficula auricularia</i> | Non-native.       |

## Orthoptera (Crickets, grasshoppers, and katydids)

Seventeen families are known from California. Another family, Prophalangopsidae, is known from southern Oregon, but has not been observed in California.

STE: Family

References:

Morris, G. K., and D. T. Gwynne. 1978. Geographical distribution and biological observations of Cyphoderris (Orthoptera: Haglidae) with a description of a new species. *Psyche* 85:147–167.

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Order             | Suborder  | Family    |
|-------------------|-----------|-----------|
| <b>Orthoptera</b> |           |           |
| Orthoptera        | Caelifera |           |
| Orthoptera        | Caelifera | Acrididae |

| Order             | Suborder  | Family            |
|-------------------|-----------|-------------------|
| <b>Orthoptera</b> | Caelifera | Romaleidae        |
| <b>Orthoptera</b> | Caelifera | Eumastacidae      |
| <b>Orthoptera</b> | Caelifera | Tanaoceridae      |
| <b>Orthoptera</b> | Caelifera | Tetrigidae        |
| <b>Orthoptera</b> | Caelifera | Tridactylidae     |
| <b>Orthoptera</b> | Ensifera  |                   |
| <b>Orthoptera</b> | Ensifera  | Gryllidae         |
| <b>Orthoptera</b> | Ensifera  | Mogoplistidae     |
| <b>Orthoptera</b> | Ensifera  | Oecanthidae       |
| <b>Orthoptera</b> | Ensifera  | Trigonidiidae     |
| <b>Orthoptera</b> | Ensifera  | Gryllotalpidae    |
| <b>Orthoptera</b> | Ensifera  | Myrmecophilidae   |
| <b>Orthoptera</b> | Ensifera  | Prophalangopsidae |
| <b>Orthoptera</b> | Ensifera  | Rhaphidophoridae  |
| <b>Orthoptera</b> | Ensifera  | Anostostomatidae  |
| <b>Orthoptera</b> | Ensifera  | Stenopelmatidae   |
| <b>Orthoptera</b> | Ensifera  | Tettigoniidae     |

## Embiidina (Webspinners)

STE: Order

Three species in two families are known in California. Ross (1957) provides a key to the taxa. However, the taxonomy appears to be in flux, and this group should be left at Order.

References:

Ross, E. S. 1957. The Embioptera of California. Bulletin of the California Insect Survey 6:1–11.

| Order     | Notes                 |
|-----------|-----------------------|
| Embiidina | Synonymous Embioptera |

## Mantodea (Mantises)

STE: Family

This group includes several native and introduced species.

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Order    | Family         | Author | Notes  |
|----------|----------------|--------|--|
| Mantodea |                |        |  |
| Mantodea | Mantidae       |        | Includes the native California mantis ( <i>Stagmomantis californica</i> ), as well as the non-native praying mantis ( <i>Mantis religiosa</i> ), and Chinese mantis ( <i>Tenodera sinensis</i> ) |
| Mantodea | Amelidae       |        | Previously in family Mantidae  |
| Mantodea | Eremiaphilidae |        |  |
| Mantodea | Tarachodidae   |        | Includes non-native Mediterranean mantis ( <i>Iris oratoria</i> )  |

## Hemiptera (True bugs)

STE: Family, where possible

Schuh and Weirauch (2020) is the most up-to-date resource for identifications, but Witfield et al. (2013) should be sufficient.

References:

Schuh, R. T., and C. Weirauch. 2020. True bugs of the world (Hemiptera: Heteroptera): classification and natural history. Second edition. Siri Scientific Press, Manchester.

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Suborder           | Infraorder  | Superfamily    | Family         | Genus | Species | Notes  |
|--------------------|-------------|----------------|----------------|-------|---------|--|
| <b>Heteroptera</b> |             |                |                |       |         |  |
| Heteroptera        | Nepomorpha  |                |                |       |         |  |
| Heteroptera        | Nepomorpha  | Nepoidea       |                |       |         |  |
| Heteroptera        | Nepomorpha  | Nepoidea       | Belostomatidae |       |         | Aquatic  |
| Heteroptera        | Nepomorpha  | Nepoidea       | Nepidae        |       |         | Aquatic  |
| Heteroptera        | Nepomorpha  | Ochteroidea    |                |       |         |  |
| Heteroptera        | Nepomorpha  | Ochteroidea    | Gelastocoridae |       |         | Shore dwellers   |
| Heteroptera        | Nepomorpha  | Ochteroidea    | Ochteridae     |       |         | Shore dwellers   |
| Heteroptera        | Nepomorpha  | Corixoidea     |                |       |         |  |
| Heteroptera        | Nepomorpha  | Corixoidea     | Corixidae      |       |         | Aquatic  |
| Heteroptera        | Nepomorpha  | Naucoroidea    |                |       |         |  |
| Heteroptera        | Nepomorpha  | Naucoroidea    | Naucoridae     |       |         | Aquatic  |
| Heteroptera        | Nepomorpha  | Notonectoidea  |                |       |         |  |
| Heteroptera        | Nepomorpha  | Notonectoidea  | Notonectidae   |       |         | Aquatic  |
| Heteroptera        | Nepomorpha  | Notonectoidea  | Pleidae        |       |         | Aquatic  |
| Heteroptera        | Gerromorpha |                |                |       |         |  |
| Heteroptera        | Gerromorpha | Mesoveloidea   |                |       |         |  |
| Heteroptera        | Gerromorpha | Mesoveloidea   | Mesovelidae    |       |         | Surface dwellers   |
| Heteroptera        | Gerromorpha | Hebroidea      | Hebridae       |       |         | Aquatic  |
| Heteroptera        | Gerromorpha | Hydrometroidea |                |       |         |  |
| Heteroptera        | Gerromorpha | Hydrometroidea | Hydrometridae  |       |         | Surface dwellers   |
| Heteroptera        | Gerromorpha | Hydrometroidea | Macroveliidae  |       |         | Aquatic; 2 species; only <i>Macrovelia hornii</i> likely to show up in samples |
| Heteroptera        | Gerromorpha | Gerroidea      |                |       |         |  |

| <b>Suborder</b>    | <b>Infraorder</b>        | <b>Superfamily</b>   | <b>Family</b>          | <b>Genus</b> | <b>Species</b> | <b>Notes</b>  |
|--------------------|--------------------------|----------------------|------------------------|--------------|----------------|---|
| <b>Heteroptera</b> | <b>Gerromorpha</b>       | <b>Gerroidea</b>     | <b>Gerridae</b>        |              |                | Surface dwellers; apterous forms may walk from puddle to puddle and show up in these samples      |
| <b>Heteroptera</b> | <b>Gerromorpha</b>       | <b>Gerroidea</b>     | <b>Veliidae</b>        |              |                | Surface dwellers  |
| <b>Heteroptera</b> | <b>Dipsocomorpha</b>     |                      |                        |              |                |   |
| <b>Heteroptera</b> | <b>Dipsocomorpha</b>     |                      | <b>Ceratocombidae</b>  |              |                | Shore dwellers; <i>Ceratocombus</i> has been recorded from CA but unlikely to show up in samples. |
| <b>Heteroptera</b> | <b>Enicocephalmorpha</b> |                      |                        |              |                |   |
| <b>Heteroptera</b> | <b>Enicocephalmorpha</b> |                      | <b>Enicocephalidae</b> |              |                |   |
| <b>Heteroptera</b> | <b>Leptopodomorpha</b>   |                      |                        |              |                |   |
| <b>Heteroptera</b> | <b>Leptopodomorpha</b>   | <b>Leptopodoidea</b> |                        |              |                |   |
| <b>Heteroptera</b> | <b>Leptopodomorpha</b>   | <b>Leptopodoidea</b> | <b>Leptopodidae</b>    |              |                | Single introduced species ( <i>Patapus spinosus</i> ), not common in US                           |
| <b>Heteroptera</b> | <b>Leptopodomorpha</b>   | <b>Salдоidea</b>     |                        |              |                |   |
| <b>Heteroptera</b> | <b>Leptopodomorpha</b>   | <b>Salдоidea</b>     | <b>Saldidae</b>        |              |                | Shore dwellers  |
| <b>Heteroptera</b> | <b>Cimicomorpha</b>      |                      |                        |              |                |   |
| <b>Heteroptera</b> | <b>Cimicomorpha</b>      | <b>Reduvoidea</b>    |                        |              |                |   |

| <b>Suborder</b>    | <b>Infraorder</b> | <b>Superfamily</b> | <b>Family</b>    | <b>Genus</b> | <b>Species</b> | <b>Notes</b>  |
|--------------------|-------------------|--------------------|------------------|--------------|----------------|---|
| <b>Heteroptera</b> | Cimicomorpha      | Reduvoidea         | Reduviidae       |              |                |   |
| <b>Heteroptera</b> | Cimicomorpha      | Naboidea           |                  |              |                |   |
| <b>Heteroptera</b> | Cimicomorpha      | Naboidea           | Nabidae          |              |                |   |
| <b>Heteroptera</b> | Cimicomorpha      | Cimicoidea         |                  |              |                |   |
| <b>Heteroptera</b> | Cimicomorpha      | Cimicoidea         | Anthocoridae     |              |                | Lasiochilidae and Lyctocoridae recently given family status; three families may not be separable. |
| <b>Heteroptera</b> | Cimicomorpha      | Cimicoidea         | Lasiochilidae    |              |                | recently split from Anthocoridae; not separable from Anthocoridae and Lyctocoridae?               |
| <b>Heteroptera</b> | Cimicomorpha      | Cimicoidea         | Lyctocoridae     |              |                | recently split from Anthocoridae; not separable from Anthocoridae and Lasiochilidae?              |
| <b>Heteroptera</b> | Cimicomorpha      | Miroidea           |                  |              |                |   |
| <b>Heteroptera</b> | Cimicomorpha      | Miroidea           | Thaumastocoridae |              |                | single introduced species   |

| Suborder           | Infraorder      | Superfamily    | Family           | Genus          | Species                   | Notes   |
|--------------------|-----------------|----------------|------------------|----------------|---------------------------|---|
|                    |                 |                |                  |                |                           | <i>Thaumastocoris peregrinus</i><br>Carpintero and Dellape; pest of <i>Eucalyptus</i> |
| <b>Heteroptera</b> | Cimicomorpha    | Miroidea       | Thaumastocoridae | Thaumastocoris |                           |   |
| <b>Heteroptera</b> | Cimicomorpha    | Miroidea       | Thaumastocoridae | Thaumastocoris | Thaumastocoris peregrinus |   |
| <b>Heteroptera</b> | Cimicomorpha    | Miroidea       | Miridae          |                |                           |   |
| <b>Heteroptera</b> | Cimicomorpha    | Miroidea       | Tingidae         |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Aradoidea      |                  |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Aradoidea      | Aradidae         |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pentatomoidea  |                  |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pentatomoidea  | Acanthosomatidae |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pentatomoidea  | Cydnidae         |                |                           | includes Thyreocorinae, formerly considered separate family                           |
| <b>Heteroptera</b> | Pentatomomorpha | Pentatomoidea  | Pentatomidae     |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pentatomoidea  | Scutellaridae    |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pyrrhocoroidea |                  |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pyrrhocoroidea | Largidae         |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Pyrrhocoroidea | Pyrrhocoridae    |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Coreoidea      |                  |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Coreoidea      | Alydidae         |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Coreoidea      | Coreidae         |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Coreoidea      | Rhopalidae       |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Lygaeoidea     |                  |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Lygaeoidea     | Rhyparochromidae |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Lygaeoidea     | Pachygronthidae  |                |                           |   |
| <b>Heteroptera</b> | Pentatomomorpha | Lygaeoidea     | Heterogastridae  |                |                           |   |

| <b>Suborder</b>       | <b>Infraorder</b> | <b>Superfamily</b> | <b>Family</b>   | <b>Genus</b> | <b>Species</b> | <b>Notes</b> |
|-----------------------|-------------------|--------------------|-----------------|--------------|----------------|--------------|
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Piesmatidae     |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Berytidae       |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Cymidae         |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Artheneidae     |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Oxycarenidae    |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Geocoridae      |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Lygaeidae       |              |                |              |
| <b>Heteroptera</b>    | Pentatomomorpha   | Lygaeoidea         | Blissidae       |              |                |              |
| <b>Auchenorrhynca</b> |                   |                    |                 |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      |                    |                 |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Cercopoidea        |                 |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Cercopoidea        | Aphrophoridae   |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Cercopoidea        | Cercopidae      |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Cercopoidea        | Clastropteridae |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Cicadoidea         | Cicadidae       |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Membracoidea       |                 |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Membracoidea       | Cicadellidae    |              |                |              |
| <b>Auchenorrhynca</b> | Cicadomorpha      | Membracoidea       | Membracidae     |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     |                    |                 |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Delphacoidea       |                 |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Delphacoidea       | Cixiidae        |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Delphacoidea       | Delphacidae     |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        |                 |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Acanaloniidae   |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Achilidae       |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Caliscelidae    |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Derbidae        |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Dictyopharidae  |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Flatidae        |              |                |              |
| <b>Auchenorrhynca</b> | Fulgoromorpha     | Fulgoroidea        | Fulgoridae      |              |                |              |

| <b>Suborder</b> | <b>Infraorder</b> | <b>Superfamily</b> | <b>Family</b> | <b>Genus</b> | <b>Species</b> | <b>Notes</b>   |
|-----------------|-------------------|--------------------|---------------|--------------|----------------|--|
| Auchenorrhynca  | Fulgoromorpha     | Fulgoroidea        | Issidae       |              |                |  |
| Auchenorrhynca  | Fulgoromorpha     | Fulgoroidea        | Kinnaridae    |              |                |  |
| Auchenorrhynca  | Fulgoromorpha     | Fulgoroidea        | Tropiduchidae |              |                |  |
| Sternorrhynca   |                   |                    |               |              |                |  |
| Sternorrhynca   |                   | Aleyrodoidea       |               |              |                |  |
| Sternorrhynca   |                   | Aleyrodoidea       | Aleyrodidae   |              |                |  |
| Sternorrhynca   |                   | Aphidoidea         |               |              |                |  |
| Sternorrhynca   |                   | Aphidoidea         | Aphididae     |              |                |  |
| Sternorrhynca   |                   | Coccoidea          |               |              |                | several families known from CA; leave ID at Coccoidea  |
| Sternorrhynca   |                   | Phylloxeroidea     |               |              |                |  |
| Sternorrhynca   |                   | Psylloidea         |               |              |                | several families known from CA; leave ID at Psylloidea |

## Raphidioptera (Snakeflies)

STE: Family, Inocelliidae to genus

Two families are found in the western U.S., with a total of 3 genera and 21 species (Penny et al. 1997). Whitfield et al. (2013) is a good resource for identifying adults, but Stehr (1991) should be used for larvae.

References:

Penny, N. D., P. A. Adams, and L. A. Strange. 1997. Species catalog of the Neuroptera, Megaloptera, and Raphidioptera of America North of Mexico. Proceedings of the California Academy of Sciences 50:39–114.

Stehr, F. W. 1991. Immature insects: Volume II. Kendall Hunt, Dubuque, IA.

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Order         | Family       | Genus | Notes   |
|---------------|--------------|-------|---|
| Raphidioptera |              |       |   |
| Raphidioptera | Raphidiidae  |       | Two genera in North America ( <i>Agulla</i> and <i>Alena</i> ), but they are difficult to separate. |
| Raphidioptera | Inocelliidae |       |   |
| Raphidioptera | Inocelliidae | Negha | Only one genus in North America   |

## Neuroptera (Lacewings)

STE: Family

Whitfield et al. (2013) is a good resource for identifying adults, but Stehr (1991) should be used for larvae. Chrysopidae are most likely to be encountered.

References:

Stehr, F. W. 1991. Immature insects: Volume II. Kendall Hunt, Dubuque, IA.

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Order      | Family      | Notes |
|------------|-------------|-------|
| Neuroptera |             |       |
| Neuroptera | Berothidae  |       |
| Neuroptera | Chrysopidae |       |

| Order      | Family          | Notes   |
|------------|-----------------|---------|
| Neuroptera | Coniopterygidae |         |
| Neuroptera | Dilaridae       |         |
| Neuroptera | Hemerobiidae    |         |
| Neuroptera | Ithonidae       |         |
| Neuroptera | Mantispidae     |         |
| Neuroptera | Myrmeleontidae  |         |
| Neuroptera | Sisyridae       | Aquatic |

## Coleoptera (Beetles)

STE: Family, where possible

An extremely diverse group with over 1,000 species in California. The most important families in terms of diversity in ephemeral and intermittent streams are the darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), and the ground beetles (Carabidae). Other major groups include leaf beetles (Chrysomelidae), weevils (Curculionidae), dung beetles (Scarabaeidae). Fully aquatic families (e.g., Dytiscidae, Hydrophilidae) are excluded. Larvae are left at Order. The keys in Arnett and Thomas (2001, 2002) should enable identification of these 113 families for adult life stages, but Stehr (1987, 1991) should be used for larvae. Families in Arnett and Thomas (2001, 2002) not mentioned here are either not known from California or are unlikely to be collected by standard sampling protocols.

### References:

Arnett, R. H., and M. C. Thomas (Eds.). 2001. American Beetles, Volume I: Archostemata, Myxophaga, Adephaga, Polyphaga: Staphyliniformia. CRC Press, Boca Raton, Fla.

Arnett, R. H., and M. C. Thomas (Eds.). 2002. American Beetles, Volume II: Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press, Boca Raton, Fla.

Stehr, F. W. 1987. Immature insects: Volume I. Kendall Hunt, Dubuque, IA.

Stehr, F. W. 1991. Immature insects: Volume II. Kendall Hunt, Dubuque, IA.

| Order      | Suborder | Superfamily | Family      | Notes   |
|------------|----------|-------------|-------------|---------|
| Coleoptera |          |             |             |         |
| Coleoptera | Adephaga |             |             |         |
| Coleoptera | Adephaga |             | Amphizoidae | Aquatic |
| Coleoptera | Adephaga |             | Carabidae   |         |
| Coleoptera | Adephaga |             | Dytiscidae  | Aquatic |
| Coleoptera | Adephaga |             | Gyrinidae   | Aquatic |
| Coleoptera | Adephaga |             | Haliplidae  | Aquatic |
| Coleoptera | Adephaga |             | Noteridae   | Aquatic |

| Order      | Suborder     | Superfamily    | Family          | Notes                  |
|------------|--------------|----------------|-----------------|------------------------|
| Coleoptera | Adephaga     |                | Rhysodidae      | May be under Carabidae |
| Coleoptera | Adephaga     |                | Trachypachidae  |                        |
| Coleoptera | Archostemata |                |                 |                        |
| Coleoptera | Archostemata |                | Cupedidae       |                        |
| Coleoptera | Archostemata |                | Micromalthidae  |                        |
| Coleoptera | Myxophaga    |                |                 |                        |
| Coleoptera | Myxophaga    |                | Hydroscaphidae  | Aquatic                |
| Coleoptera | Myxophaga    |                | Sphaeriusidae   | Was Microsporidae      |
| Coleoptera | Polyphaga    |                |                 |                        |
| Coleoptera | Polyphaga    | Bostrichoidea  |                 |                        |
| Coleoptera | Polyphaga    | Bostrichoidea  | Bostrichidae    |                        |
| Coleoptera | Polyphaga    | Bostrichoidea  | Dermestidae     |                        |
| Coleoptera | Polyphaga    | Bostrichoidea  | Nosodendridae   |                        |
| Coleoptera | Polyphaga    | Bostrichoidea  | Ptinidae        | Includes Anobiidae     |
| Coleoptera | Polyphaga    | Buprestoidea   |                 |                        |
| Coleoptera | Polyphaga    | Buprestoidea   | Buprestidae     |                        |
| Coleoptera | Polyphaga    | Buprestoidea   | Schizopodidae   |                        |
| Coleoptera | Polyphaga    | Byrrhoidea     |                 |                        |
| Coleoptera | Polyphaga    | Byrrhoidea     | Byrrhidae       |                        |
| Coleoptera | Polyphaga    | Byrrhoidea     | Dryopidae       | Aquatic                |
| Coleoptera | Polyphaga    | Byrrhoidea     | Elmidae         | Aquatic                |
| Coleoptera | Polyphaga    | Byrrhoidea     | Eulichadidae    | Aquatic                |
| Coleoptera | Polyphaga    | Byrrhoidea     | Heteroceridae   |                        |
| Coleoptera | Polyphaga    | Byrrhoidea     | Limnichidae     |                        |
| Coleoptera | Polyphaga    | Byrrhoidea     | Psephenidae     | Aquatic                |
| Coleoptera | Polyphaga    | Byrrhoidea     | Ptilodactylidae | Aquatic                |
| Coleoptera | Polyphaga    | Chrysomeloidea |                 |                        |
| Coleoptera | Polyphaga    | Chrysomeloidea | Cerambycidae    |                        |
| Coleoptera | Polyphaga    | Chrysomeloidea | Chrysomelidae   |                        |
| Coleoptera | Polyphaga    | Chrysomeloidea | Megalopodidae   |                        |
| Coleoptera | Polyphaga    | Chrysomeloidea | Orsodacnidae    |                        |
| Coleoptera | Polyphaga    | Cleroidea      |                 |                        |
| Coleoptera | Polyphaga    | Cleroidea      | Cleridae        |                        |
| Coleoptera | Polyphaga    | Cleroidea      | Melyridae       |                        |
| Coleoptera | Polyphaga    | Cleroidea      | Trogossitidae   |                        |
| Coleoptera | Polyphaga    | Coccinelloidea |                 |                        |
| Coleoptera | Polyphaga    | Coccinelloidea | Anamorphidae    |                        |
| Coleoptera | Polyphaga    | Coccinelloidea | Bothrideridae   |                        |
| Coleoptera | Polyphaga    | Coccinelloidea | Coccinellidae   |                        |
| Coleoptera | Polyphaga    | Coccinelloidea | Corylophidae    |                        |
| Coleoptera | Polyphaga    | Coccinelloidea | Endomychidae    |                        |
| Coleoptera | Polyphaga    | Coccinelloidea | Latridiidae     |                        |

| Order      | Suborder  | Superfamily    | Family           | Notes                   |
|------------|-----------|----------------|------------------|-------------------------|
| Coleoptera | Polyphaga | Coccinelloidea | Mycetidae        |                         |
| Coleoptera | Polyphaga | Cucujoidea     |                  |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Biphyllidae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Bothrideridae    |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Byturidae        |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Cerylonidae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Corylophidae     |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Cryptophagidae   |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Cucujidae        |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Cybocephalidae   | Split from Nitidulidae  |
| Coleoptera | Polyphaga | Cucujoidea     | Endomychidae     |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Erotylidae       | Includes Languriidae    |
| Coleoptera | Polyphaga | Cucujoidea     | Kateretidae      | Formerly Brachypteridae |
| Coleoptera | Polyphaga | Cucujoidea     | Laemophloeidae   |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Latridiidae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Monotomidae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Nitidulidae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Passandridae     |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Phalacridae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Silvanidae       |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Smicripidae      |                         |
| Coleoptera | Polyphaga | Cucujoidea     | Sphindidae       |                         |
| Coleoptera | Polyphaga | Curculionoidea |                  |                         |
| Coleoptera | Polyphaga | Curculionoidea | Anthribidae      |                         |
| Coleoptera | Polyphaga | Curculionoidea | Attelabidae      |                         |
| Coleoptera | Polyphaga | Curculionoidea | Brentidae        |                         |
| Coleoptera | Polyphaga | Curculionoidea | Curculionidae    |                         |
| Coleoptera | Polyphaga | Curculionoidea | Nemonychidae     |                         |
| Coleoptera | Polyphaga | Dascilloidea   |                  |                         |
| Coleoptera | Polyphaga | Dascilloidea   | Dascillidae      |                         |
| Coleoptera | Polyphaga | Dascilloidea   | Rhipiceridae     |                         |
| Coleoptera | Polyphaga | Derontoidea    |                  |                         |
| Coleoptera | Polyphaga | Derontoidea    | Derodontidae     |                         |
| Coleoptera | Polyphaga | Elateroidea    |                  |                         |
| Coleoptera | Polyphaga | Elateroidea    | Artematopodidae  |                         |
| Coleoptera | Polyphaga | Elateroidea    | Brachypsectridae |                         |
| Coleoptera | Polyphaga | Elateroidea    | Cantharidae      |                         |
| Coleoptera | Polyphaga | Elateroidea    | Cerophytidae     |                         |
| Coleoptera | Polyphaga | Elateroidea    | Elateridae       |                         |
| Coleoptera | Polyphaga | Elateroidea    | Eucnemidae       |                         |
| Coleoptera | Polyphaga | Elateroidea    | Lampyridae       |                         |
| Coleoptera | Polyphaga | Elateroidea    | Lycidae          |                         |

| Order      | Suborder  | Superfamily    | Family             | Notes                              |
|------------|-----------|----------------|--------------------|------------------------------------|
| Coleoptera | Polyphaga | Elateroidea    | Omethidae          |                                    |
| Coleoptera | Polyphaga | Elateroidea    | Phengodidae        |                                    |
| Coleoptera | Polyphaga | Elateroidea    | Throscidae         |                                    |
| Coleoptera | Polyphaga | Histeroidea    |                    |                                    |
| Coleoptera | Polyphaga | Histeroidea    | Histeridae         |                                    |
| Coleoptera | Polyphaga | Histeroidea    | Sphaeritidae       |                                    |
| Coleoptera | Polyphaga | Hydrophiloidea |                    |                                    |
| Coleoptera | Polyphaga | Hydrophiloidea | Hydrophilidae      |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  |                    |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Diphyllostomatidae |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Geotrupidae        |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Glyphyridae        |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Glaresidae         |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Hybosoridae        | Includes Ceratocanthidae           |
| Coleoptera | Polyphaga | Scarabaeoidea  | Lucanidae          |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Ochodaeida         |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Pleocomidae        |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Scarabaeidae       |                                    |
| Coleoptera | Polyphaga | Scarabaeoidea  | Trogidae           |                                    |
| Coleoptera | Polyphaga | Scirtoidea     |                    |                                    |
| Coleoptera | Polyphaga | Scirtoidea     | Clambidae          |                                    |
| Coleoptera | Polyphaga | Scirtoidea     | Eucinetidae        |                                    |
| Coleoptera | Polyphaga | Scirtoidea     | Scirtidae          |                                    |
| Coleoptera | Polyphaga | Staphylinoidea |                    |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Agyrtidae          |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Hydraenidae        |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Leiodidae          |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Ptiliidae          |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Scydmaenidae       |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Silphidae          |                                    |
| Coleoptera | Polyphaga | Staphylinoidea | Staphylinidae      |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea |                    |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Aderidae           |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Anthicidae         |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Boridae            |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Ciidae             |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Melandryidae       |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Meloidae           |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Mordellidae        |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Mycetophagidae     |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Oedemeridae        |                                    |
| Coleoptera | Polyphaga | Tenebrionoidea | Prostomidae        | Monotypic family with one species: |

| Order      | Suborder  | Superfamily    | Family           | Notes                            |
|------------|-----------|----------------|------------------|----------------------------------|
|            |           |                |                  | <i>Prostomis americanus</i>      |
| Coleoptera | Polyphaga | Tenebrionoidea | Pyrochroidae     |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Pythidae         |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Ripiphoridae     |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Salpingidae      |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Scriptiidae      | Includes Ischaliidae             |
| Coleoptera | Polyphaga | Tenebrionoidea | Stenotrachelidae |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Tenebrionidae    |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Tetramidae       |                                  |
| Coleoptera | Polyphaga | Tenebrionoidea | Zopheridae       | Includes Colydiidae, Monomatidae |

## Hymenoptera: Non-formicidae (Bees, velvet ants, wasps)

STE: Order, Mutillidae and Apidae to Family

Bees (Apidae) and velvet ants (Mutillidae) should be taken to family. However, other taxa (e.g., Sphecidae, Ichneumonidae) should be left at Order.

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Order       | Family     |
|-------------|------------|
| Hymenoptera |            |
| Hymenoptera | Apidae     |
| Hymenoptera | Mutillidae |

## Hymenoptera: Formicidae (Ants)

STE: Genus, species where possible (i.e., *Linepithema*, *Tapinoma*)

Ants (Formicidae), along with beetles and spiders, represent the greatest diversity and abundance of terrestrial arthropods in dry streambeds. Several non-native taxa have had large impacts on native flora and fauna (e.g., Argentine ants, *Linepithema humile*), and every sample should be investigated for their presence. California has 281 ant species, of which 255 are native, and 39 are endemic to the state (Ward 2005).

References:

Ward, P. S. 2005. A synoptic review of the ants of California (Hymenoptera: Formicidae). Zootaxa 936:1.

| Family     | Subfamily      | Genus              | Species                        | Notes  |
|------------|----------------|--------------------|--------------------------------|--|
| Formicidae |                |                    |                                |  |
| Formicidae | Amblyoponinae  |                    |                                |  |
| Formicidae | Amblyoponinae  | <i>Amblyopone</i>  |                                | Best to leave at genus   |
| Formicidae | Amblyoponinae  | <i>Amblyopone</i>  | <i>Amblyopone oregonensis</i>  |  |
| Formicidae | Amblyoponinae  | <i>Amblyopone</i>  | <i>Amblyopone pallidus</i>     |  |
| Formicidae | Cerapachyinae  |                    |                                |  |
| Formicidae | Cerapachyinae  | <i>Cerapachys</i>  |                                | Subterranean, and rarely encountered.  |
| Formicidae | Dolichoderinae |                    |                                |  |
| Formicidae | Dolichoderinae | <i>Dorymyrmex</i>  |                                |  |
| Formicidae | Dolichoderinae | <i>Forelius</i>    |                                | Two species in California ( <i>D. mccooki</i> , <i>D. pruinosus</i> ) difficult to distinguish |
| Formicidae | Dolichoderinae | <i>Forelius</i>    | <i>Forelius mccooki</i>        |  |
| Formicidae | Dolichoderinae | <i>Forelius</i>    | <i>Forelius pruinosus</i>      |  |
| Formicidae | Dolichoderinae | <i>Linepithema</i> |                                | One species in genus in California   |
| Formicidae | Dolichoderinae | <i>Linepithema</i> | <i>Linepithema humile</i>      | Non-native Argentine ant   |
| Formicidae | Dolichoderinae | <i>Liometopum</i>  |                                | Two widespread species in California. Best left at genus.                                      |
| Formicidae | Dolichoderinae | <i>Liometopum</i>  | <i>Liometopum luctuosum</i>    |  |
| Formicidae | Dolichoderinae | <i>Liometopum</i>  | <i>Liometopum occidentale</i>  |  |
| Formicidae | Dolichoderinae | <i>Tapinoma</i>    |                                |  |
| Formicidae | Dolichoderinae | <i>Tapinoma</i>    | <i>Tapinoma melanocephalum</i> | Introduced   |
| Formicidae | Dolichoderinae | <i>Tapinoma</i>    | <i>Tapinoma sessile</i>        | Common and widespread except in deserts or areas   |

| Family     | Subfamily      | Genus                | Species                        | Notes   |
|------------|----------------|----------------------|--------------------------------|---|
|            |                |                      |                                | invaded by <i>Linepithema humile</i> .  |
| Formicidae | Dolichoderinae | <i>Technomyrmex</i>  |                                |   |
| Formicidae | Dolichoderinae | <i>Technomyrmex</i>  | <i>Technomyrmex albipes</i>    | One species (introduced) in genus   |
| Formicidae | Ectoninae      |                      |                                |   |
| Formicidae | Ectoninae      | <i>Neivamyrmex</i>   |                                | Army ants   |
| Formicidae | Formicinae     |                      |                                |   |
| Formicidae | Formicinae     | <i>Brachymyrme</i>   |                                |   |
| Formicidae | Formicinae     | <i>Brachymyrme</i>   | <i>Brachymyrme mex depilis</i> | Only species in this genus occurs in California   |
| Formicidae | Formicinae     | <i>Camponotus</i>    |                                | Diverse group, with no single key covering all species. Leave at genus  |
| Formicidae | Formicinae     | <i>Formica</i>       |                                | Most prevalent in montane habitats.   |
| Formicidae | Formicinae     | <i>Lasius</i>        |                                |   |
| Formicidae | Formicinae     | <i>Myrmecosystus</i> |                                |   |
| Formicidae | Formicinae     | <i>Paratrechina</i>  |                                | One introduced species ( <i>P. longicornis</i> ), plus several native species.                                  |
| Formicidae | Formicinae     | <i>Plagiolepis</i>   |                                |   |
| Formicidae | Formicinae     | <i>Plagiolepis</i>   | <i>Plagiolepis alluaudi</i>    | Single introduced species.  |
| Formicidae | Formicinae     | <i>Polygerus</i>     |                                | May be a single, highly variable species ( <i>P. breviceps</i> )  |
| Formicidae | Formicinae     | <i>Prenolepis</i>    |                                |   |
| Formicidae | Myrmecinae     |                      |                                |   |
| Formicidae | Myrmecinae     | <i>Acromyrmex</i>    |                                |   |
| Formicidae | Myrmecinae     | <i>Acromyrmex</i>    | <i>Acromyrmex versicolor</i>   | One species in California, confined to southern deserts   |
| Formicidae | Myrmecinae     | <i>Aphaenogaster</i> |                                | Six species in California, including one endemic to the channel islands.  |
| Formicidae | Myrmecinae     | <i>Cardiocondyla</i> |                                | Two species are non-native and adapted to urban environments, and can co-exist with <i>Linepithema humile</i> . |

| Family     | Subfamily  | Genus                | Species                            | Notes  |
|------------|------------|----------------------|------------------------------------|--|
| Formicidae | Myrmecinae | <i>Cardiocondyla</i> | <i>Cardiocondyla mauritanica</i>   | Non-native.  |
| Formicidae | Myrmecinae | <i>Cardiocondyla</i> | <i>Cardiocondyla minutior</i>      |  |
| Formicidae | Myrmecinae | <i>Crematogaster</i> |                                    | Large, cosmopolitan genus.   |
| Formicidae | Myrmecinae | <i>Formicoxenus</i>  |                                    |  |
| Formicidae | Myrmecinae | <i>Formicoxenus</i>  | <i>Formicoxenus diversipilosus</i> | Single species found in northern California, where it lives as a guest-ant in nests of <i>Formica rufa</i> -group. |
| Formicidae | Myrmecinae | <i>Leptothorax</i>   |                                    | Leave at genus.  |
| Formicidae | Myrmecinae | <i>Manica</i>        |                                    | Four species in California, all in mountains or high desert  |
| Formicidae | Myrmecinae | <i>Messor</i>        |                                    | Seven species in California  |
| Formicidae | Myrmecinae | <i>Monomorium</i>    |                                    |  |
| Formicidae | Myrmecinae | <i>Monomorium</i>    | <i>Monomorium egratogyna</i>       | Native species, formerly treated as several separate species.  |
| Formicidae | Myrmecinae | <i>Monomorium</i>    | <i>Monomorium pharaonis</i>        | Non-native pest in urban environments  |
| Formicidae | Myrmecinae | <i>Myrmecina</i>     |                                    |  |
| Formicidae | Myrmecinae | <i>Myrmecina</i>     | <i>Myrmecina americana</i>         | Only species found in California   |
| Formicidae | Myrmecinae | <i>Myrmica</i>       |                                    |  |
| Formicidae | Myrmecinae | <i>Pheidole</i>      |                                    | Very large genus, with many native and 3 introduced species in California  |
| Formicidae | Myrmecinae | <i>Pogonomyrmex</i>  |                                    |  |
| Formicidae | Myrmecinae | <i>Pyramica</i>      |                                    | Two endemic and one introduced species in California   |
| Formicidae | Myrmecinae | <i>Rogeria</i>       |                                    | Single undescribed species collected in Orange County  |
| Formicidae | Myrmecinae | <i>Solenopsis</i>    |                                    |  |

| Family     | Subfamily        | Genus               | Species                         | Notes  |
|------------|------------------|---------------------|---------------------------------|--|
| Formicidae | Myrmecinae       | <i>Solenopsis</i>   | <i>Solenopsis xyloni</i>        | Widespread native fire-ant   |
| Formicidae | Myrmecinae       | <i>Solenopsis</i>   | <i>Solenopsis invicta</i>       | Widespread invasive fire-ant   |
| Formicidae | Myrmecinae       | <i>Stenamma</i>     |                                 |  |
| Formicidae | Myrmecinae       | <i>Strumigenys</i>  |                                 |  |
| Formicidae | Myrmecinae       | <i>Strumigenys</i>  | <i>Strumigenys silvestrii</i>   | Single, non-native species found in California   |
| Formicidae | Myrmecinae       | <i>Temnothorax</i>  |                                 | Twenty species in California   |
| Formicidae | Myrmecinae       | <i>Tetramorium</i>  |                                 | Two species in California  |
| Formicidae | Myrmecinae       | <i>Tetramorium</i>  | <i>Tetramorium spinosum</i>     | Native species   |
| Formicidae | Myrmecinae       | <i>Tetramorium</i>  | <i>Tetramorium caespitum</i>    | Non-native european pavement ant   |
| Formicidae | Myrmecinae       | <i>Wasmannia</i>    |                                 |  |
| Formicidae | Myrmecinae       | <i>Wasmannia</i>    | <i>Wasmannia auropunctata</i>   | Native to neotropics. Found but not yet established in Southern California                               |
| Formicidae | Ponerinae        |                     |                                 |  |
| Formicidae | Ponerinae        | <i>Hypoponera</i>   |                                 | Four species known in California, including one undescribed species.                                     |
| Formicidae | Proceratiinae    |                     |                                 |  |
| Formicidae | Proceratiinae    | <i>Proceratium</i>  |                                 |  |
| Formicidae | Proceratiinae    | <i>Proceratium</i>  | <i>Proceratium californicum</i> | One species, endemic to the state. Found in the Central Valley oak woodlands, chaparral, and grasslands. |
| Formicidae | Pseudomyrmecinae |                     |                                 |  |
| Formicidae | Pseudomyrmecinae | <i>Pseudomyrmex</i> |                                 |  |
| Formicidae | Pseudomyrmecinae | <i>Pseudomyrmex</i> | <i>Pseudomyrmex apache</i>      | Native, widespread in California   |
| Formicidae | Pseudomyrmecinae | <i>Pseudomyrmex</i> | <i>Pseudomyrmex pallidus</i>    | Native, confined to southern California  |

## Other insects

STE: Order

These may be keyed out following Whitfield et al. (2013).

References:

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. Daly and Doyen's introduction to insect biology and diversity. 3rd ed. Oxford University Press, New York.

| Class   | Order          | Notes                            |
|---------|----------------|----------------------------------|
| Insecta |                |                                  |
| Insecta | Phasmida       |                                  |
| Insecta | Blattodea      |                                  |
| Insecta | Thysanoptera   |                                  |
| Insecta | Psocodea       |                                  |
| Insecta | Lepidoptera    |                                  |
| Insecta | Mecoptera      |                                  |
| Insecta | Ephemeroptera  | Aquatic                          |
| Insecta | Plecoptera     | Aquatic                          |
| Insecta | Trichoptera    | Aquatic                          |
| Insecta | Odonata        | Aquatic                          |
| Insecta | Megaloptera    | Aquatic                          |
| Insecta | Zoraptera      | Unlikely to encounter in samples |
| Insecta | Diptera        |                                  |
| Insecta | Grylloblatodea | Unlikely to encounter in samples |

## CITED LITERATURE

- Arnett, R. H., and M. C. Thomas (Eds.). 2001. American Beetles, Volume I: Archostemata, Myxophaga, Adephaga, Polyphaga: Staphyliniformia. CRC Press, Boca Raton, Fla.
- Arnett, R. H., and M. C. Thomas (Eds.). 2002. American Beetles, Volume II: Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press, Boca Raton, Fla.
- Bellinger, P. F., K. A. Chistiansen, and F. Janssens. 2003. Checklist of Collembola of the World. (Available from: <http://www.collembola.org>)
- Bowser, M. L. 2012. Key and checklist of the bristletails (Microcoryphia) of America north of Mexico. (Available from: [https://www.researchgate.net/profile/Matthew-Bowser-2/publication/341030994\\_Key\\_and\\_checklist\\_of\\_the\\_bristletails\\_Microcoryphia\\_of\\_America\\_north\\_of\\_Mexico/](https://www.researchgate.net/profile/Matthew-Bowser-2/publication/341030994_Key_and_checklist_of_the_bristletails_Microcoryphia_of_America_north_of_Mexico/))
- Brusca, R., V. R. Coelho, and S. Taiti. 2001. A guide to the Coastal Isopods of California. Tree of Life. (Available from: [http://tolweb.org/notes/?note\\_id=3004](http://tolweb.org/notes/?note_id=3004))
- Langston, R. L., and J. A. Powell. 1975. The earwigs of California (order Dermaptera). University of California Press, Berkeley.
- Merritt, R. W., K. W. Cummins, and M. B. Berg (Eds.). 2019. An introduction to the aquatic insects of North America.
- Moody, E. K., and J. L. Sabo. 2017. Dissimilarity in the riparian arthropod communities along surface water permanence gradients in aridland streams. *Ecohydrology* 10:e1819.
- Morris, G. K., and D. T. Gwynne. 1978. Geographical distribution and biological observations of Cyphoderris (Orthoptera: Haglidae) with a description of a new species. *Psyche* 85:147–167.
- Penny, N. D., P. A. Adams, and L. A. Strange. 1997. Species catalog of the Neuroptera, Megaloptera, and Raphidioptera of America North of Mexico. *Proceedings of the California Academy of Sciences* 50:39–114.
- Richards, A. B., and D. C. Rogers. 2011. List of Freshwater Macroinvertebrate Taxa from California and Adjacent States including Standard Taxonomic Effort Levels. Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT), Sacramento, CA. (Available from: [https://www.safit.org/Docs/STE\\_1\\_March\\_2011\\_7MB.pdf](https://www.safit.org/Docs/STE_1_March_2011_7MB.pdf))

Robinson, M. D., T. Clark, R. D. Mazor, and J. R. Olson. 2018. Field protocol for assessing the ecological health of dry-phase non-perennial rivers and streams. Page 24. Central Coast Watershed Studies Report WI-2018-XX, California State University at Monterey Bay.

Rogers, D. C., and A. B. Richards. 2006. Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Rules for the Development and Maintenance of the Standard Level of Taxonomic Effort. Page 20. Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). (Available from: [https://www.safit.org/Docs/ste\\_rules.pdf](https://www.safit.org/Docs/ste_rules.pdf))

Ross, E. S. 1957. The Embioptera of Caliofrnia. Bulletin of the California Insect Survey 6:1–11.

Schuh, R. T., and C. Weirauch. 2020. True bugs of the world (Hemiptera: Heteroptera): classification and natural history. Second edition. Siri Scientific Press, Manchester.

Shelley, R. M. 2002. Annotated Checklist Of The Millipeds Of California (Arthropoda: Diplopoda). Monographs of the Western North American Naturalist 1:90–115.

Shultz, J. W. 2018. A guide to the identification of the terrestrial Isopoda of Maryland, U.S.A. (Crustacea). ZooKeys 801:207–228.

Stehr, F. W. 1987. Immature insects: Volume I. Kendall Hunt, Dubuque, IA.

Stehr, F. W. 1991. Immature insects: Volume II. Kendall Hunt, Dubuque, IA.

Steward, A. L., T. Datry, and S. D. Langhans. 2022. The terrestrial and semi-aquatic invertebrates of intermittent rivers and ephemeral streams. Biological Reviews brv.12848.

Steward, A. L., S. D. Langhans, R. Corti, and T. Datry. 2017. The Biota of Intermittent Rivers and Ephemeral Streams: Terrestrial and Semiaquatic Invertebrates. Pages 245–271 Intermittent Rivers and Ephemeral Streams. Elsevier.

Thorp, J. H., D. C. Rogers, and A. P. Covich (Eds.). 2015. Thorp and Covich's Freshwater invertebrates. Fourth edition. Elsevier/AP, Academic Press is an imprint of Elsevier, Amsterdam ; Boston.

Ubick, D., P. Paquin, P. E. Cushing, V. D. Roth, N. Duperré, and American Arachnological Society (Eds.). 2017. Spiders of North America: An identification manual. 2nd ed. American Arachnological Society, Keene, New Hampshire.

Ward, P. S. 2005. A synoptic review of the ants of California (Hymenoptera: Formicidae). Zootaxa 936:1.

Whitfield, J. B., J. T. Doyen, A. H. Purcell, and H. V. Daly. 2013. *Daly and Doyen's introduction to insect biology and diversity*. 3rd ed. Oxford University Press, New York.

# **APPENDIX: TECHNICAL NEEDS FOR A STANDARDIZED TAXONOMIC EFFORT FOR ARTHROPODS IN CALIFORNIA AND ARIZONA DRY STREAMS AND RIVERS**

Prepared by Raphael Mazor and Susanna Theroux

*Southern California Coastal Water Research Project. Costa Mesa, CA*

## **Identify or generate more general entomological identification resources**

Whereas resources such as Merritt et al. (2019) and Thorp et al. (2015) provide a comprehensive guides for the identification of aquatic invertebrates, no comparable resource provides such a broad-based and in-depth guide for terrestrial arthropods. General entomological texts (e.g., Whitfield et al. 2013) provide a starting point, but typically do not support high levels of taxonomic resolution in any group, and exclude less common taxa altogether.

Given the substantially greater diversity of terrestrial taxa (e.g., there are 117 beetle families in the terrestrial STE compared to only 30 in the aquatic STE), creating such a resource may not be feasible. Efforts may be more wisely allocated to expand capacity to identify certain subgroups and take them to better levels of resolution. In general, we prioritize groups with the following characteristics:

- Frequently observed in samples
- Evidence of strong response to human activity
- Currently at a coarse level of resolution (e.g., Order or Family)

Based on these criteria, the following are taxonomic groups where expanded taxonomic capacity would be most beneficial:

### **Spiders**

Among spiders that could be identified to family, about five families were particularly common:

- Gnaphosidae (ground spiders; 55% of samples)
- Salticidae (jumping spiders; 50% of samples)

- Aranidae (orb weavers; 33% of samples)
- Dictynidae (mesh web weavers; 14% of samples)
- Lycosidae (wolf spiders; 13% of samples)
- Oecobiidae (wall spiders; 18% of trap samples)
- Oxyopidae (linx spiders; 16% of vegetation samples)

Efforts to achieve genus-level identifications should focus on these groups.

## Beetles

No single beetle family occurred with as great a frequency as did certain spider families. However, these beetle families should be targeted for development of identification resources:

- Chrysomelidae (leaf beetles; 20% of samples)
- Carabidae (ground beetles; 17% of samples)
- Latridiidae (minute brown scavenger beetles; 17% of samples)
- Scraptiidae (false flower beetles; 16% of samples)
- Tenebrionidae (darkling beetles; 34% of trap samples)
- Staphylinidae (rove beetles; 22% of trap samples)
- Dermestidae (carpet beetles; 19% of trap samples)
- Nitidulidae (sap-feeding beetles; 19% of trap samples)
- Coccinellidae (ladybird beetles; 25% of vegetation samples)

Although most of these groups are among the most diverse beetle families, Latridiidae and Scraptiidae have relatively less diversity (i.e., 16 and 10 genera, respectively, in North America, Arnett and Thomas 2002). Thus, genus-level identification may be more practical for some of these groups. In contrast, carabid beetles have nearly 200 genera in 15 subfamilies and 50 tribes; thus, genus-level identification for this group may be less attainable.

## Ants

Species-level identification is attainable for several groups of ants. Higher-level identification would be helpful for genera where there are a mix of native and introduced species (e.g.,

*Paratrechina*, *Pheidole*). Frequently encountered genera may also be useful to take to species level:

- *Dorymyrmex* (4 taxa in California; 22% of trap samples)
- *Crematogaster* (9 taxa in California; 19% of trap samples)
- *Monomorium* (2 taxa in California; 19% of trap samples)
- *Pogonomyrmex* (15 taxa in California; 19% of trap samples)
- *Solenopsis* (10 taxa in California; 19% of trap samples)
- *Formica* (40 taxa in California; 16% of trap samples)

Ward (2005) provides keys for most of these groups, and workshops focusing on these genera would be most beneficial.

## Other groups

These taxa occurred in more than 25% of trap or vegetation samples, and would therefore benefit from increased taxonomic resolution:

- Acari
- Microcoryphia: Meinertellidae
- Collembola: Entomobryidae
- Hemiptera: Aphididae
- Psocodea
- Dermaptera: *Euborellia*
- Thysanoptera
- Chrysopidae
- Psylloidea

## Additional sampling

WEE-CSUMB voucher collections cover dry stream habitats in coastal Southern California fairly well, but only sparsely represent streams in other parts of the Southwest or greater California.

Even within Southern California, ephemeral streams and intermittent streams with short streamflow durations are likely under-represented by voucher collection samples. Additional sampling in these areas is likely to identify a large number of taxa that should be incorporated into the STE. Taxa that are minimally represented in samples collected so far, but are known to be important in dry riverbeds in other studies (e.g., Steward et al. 2017, 2022; and Moody and Sabo 2017), include pygmy grasshoppers (Orthoptera: Tetrigidae), cellar spiders (Araneae: Pholcidae), camel crickets (Orthoptera: Rhaphidophoridae), and others. Major insect orders, like Blattodea, Isoptera, and Mantodea are not represented in collections so far. Given the large diversity of certain groups (e.g., Coleoptera families of Carabidae, Staphylinidae, and Tenebrionidae), it is likely that additional sampling will greatly increase the number of taxa in this STE.

## **Develop keys for select groups**

Although family-level keys are available for most groups of arthropods, we are unaware of genus- or species-level keys for several groups (e.g., rove beetles). Developing keys for groups of diverse taxa typically found in dry stream samples would be beneficial.

## **Identify morphospecies**

STE Level 1 relies heavily on the use of morphospecies that likely represent truly distinct species (i.e., distinct not just within a sample, but distinct across all samples analyzed by WEE-CSUMB). Efforts are underway by the California Department of Fish and Wildlife's Aquatic Bioassessment Lab to obtain species names within select groups (e.g., beetles, ants), but other groups (e.g., spiders) may require consulting additional experts.

## **Develop molecular tools**

The current STE takes most groups to Family or Order level, despite high genus- and species-level diversity in many arthropod groups. Some species can be identified fairly rapidly, but most require a great deal of expertise across many taxonomic groups. Molecular methods can support higher levels of taxonomic resolution.

We evaluated selected taxa in the STE to determine if molecular sequences for the COI barcode region were available the Barcode of Life Database (<https://boldsystems.org/>, Table 1). Queries focused on selected groups of arthropods. All families known to occur in California were queried as were selected genera or species. For some groups (e.g., Isopoda, Dermaptera, Formicidae), all terrestrial California genera were queried (as were all species of terrestrial

Isopoda and Dermaptera). For other groups, only a handful of taxa were queried (typically because they have been identified in samples collected in Southern California).

**Table 1. Number of taxa of selected groups that were queried for coverage in the Barcode of Life Database (BOLD).**

| Taxon             | Family | Subfamily | Genus | Species |
|-------------------|--------|-----------|-------|---------|
| <b>Amphipoda</b>  | 1118   | 0         | 2     | 3       |
| <b>Isopoda</b>    | 9      | 0         | 15    | 4       |
| <b>Araneae</b>    | 57     | 0         | 11    | 1       |
| <b>Collembola</b> | 29     | 0         | 0     | 0       |
| <b>Dermaptera</b> | 5      | 0         | 9     | 11      |
| <b>Hemiptera</b>  | 70     | 0         | 5     | 4       |
| <b>Orthoptera</b> | 16     | 0         | 0     | 0       |
| <b>Coleoptera</b> | 117    | 0         | 12    | 7       |
| <b>Total</b>      | 304    | 9         | 94    | 78      |

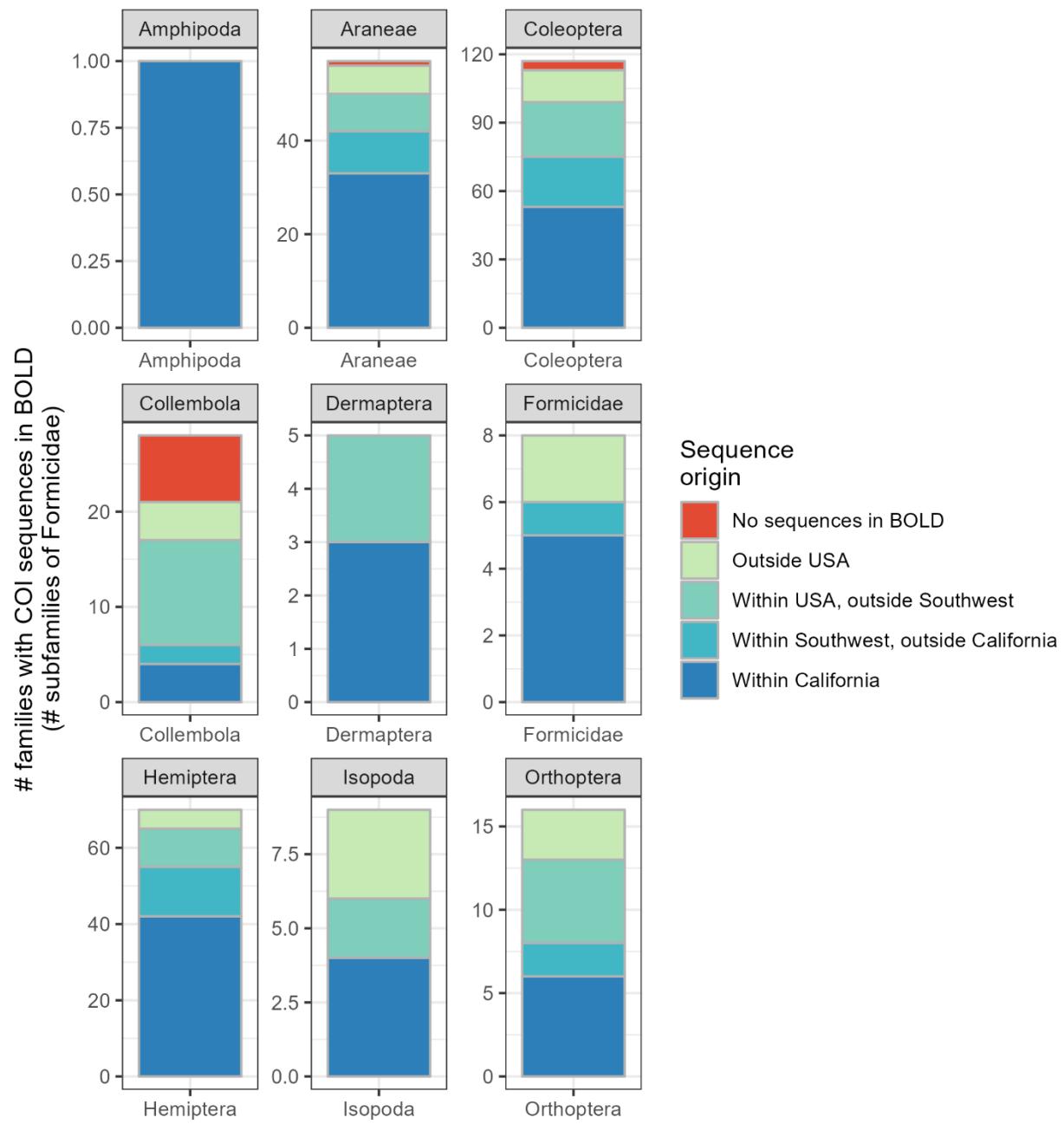
Within BOLD, we looked for sequences that target the mitochondrial COI gene. Because BOLD also had geographic metadata, we were able to tally sequences from specimens collected within California, within the Southwest but outside California (i.e., Arizona, Nevada, Utah, New Mexico, Colorado, and Texas), within the USA but outside the Southwest, or outside the USA. Sequences from California or nearby regions may improve the ability of barcode-based identification to account for regional intraspecific diversity.

At the family level, most major groups of arthropods had COI sequences in BOLD (Figure 1). All but one Araneae family (i.e., Amphinectidae), 4 beetle families (i.e., Brachypsectridae, Diphyllostomatidae, Pleocomidae, and Scydmaenidae)), and 7 Collembola families (i.e., Coenaletidae, Collophoridae, Isotagstruridae, Mackenziellidae, Pachytullbergiidae, Paleotullbergiidae, and Sturmiidae) had taxa with COI sequences in BOLD, and at least some taxa in every group had sequences from California. None of the 12 families lacking representation in BOLD have been observed in dry stream samples collected thus far. Representation of sequences from California was best for Araneae (58% of 57 families), Dermaptera (60% of 5 families), Hemiptera (60% of 70 families), Formicidae (63% of 8 subfamilies) and Amphipoda (100% of 1 family). It was worst, by far, for Collembola (14% of 28 families).

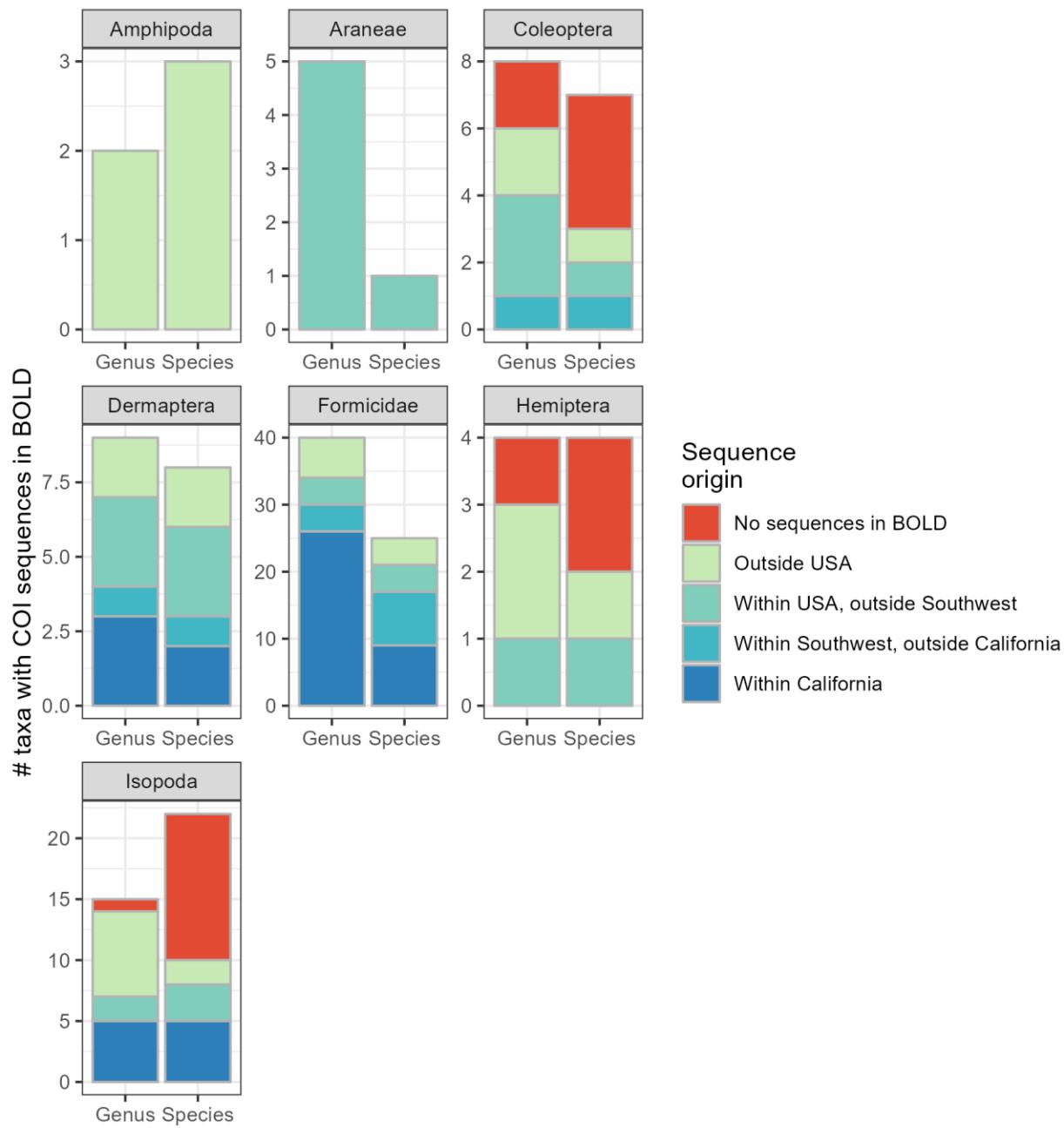
At the genus or species level, most of the queried taxa were represented in BOLD (Figure 2). Because some of these genus- and species-level queries focused on a small subset of taxa known to occur in California, they may not provide a clear picture of the adequacy of reference libraries for certain groups. The results for Dermaptera and Isopoda may be considered comprehensive. In the case of the former, all genera and all species are represented. In the case

of Isopoda, only one genus (i.e., *Detonella*) lacks representation; however, only 10 out of 22 species have sequences in BOLD. All queried genera and species of Formicidae had sequences in BOLD, although not all species that occur in California were queried (a complete list of California ant species was not available). Among other groups, the number of taxa queried is likely too limited to draw conclusions about reference libraries.

We conclude that at the family level, BOLD provides an adequate reference library for most evaluated groups, apart from Collembola. We recommend generating a list of species or genera known to occur in California for selected groups (such as beetles and spiders) to allow for a more comprehensive assessment of the capacity of BOLD to support identifications at higher levels of taxonomic resolution.



**Figure 1. Number of families (or subfamilies of Formicidae) with COI sequences in BOLD.**



**Figure 2. Number of genera or subfamilies with COI sequences in BOLD.**