California Pollinator Project

Citizen Scientist Pollinator Monitoring Guide

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The Xerces Society for Invertebrate Conservation is an international, nonprofit, member–supported organization dedicated to preserving wildlife and its habitat through the conservation of invertebrates. The Society promotes protection of invertebrates and their habitat through science–based advocacy, conservation, and education projects. Its work focuses on three principal areas—endangered species, watershed health, and pollinator conservation. For more information about the Society or on becoming a member, please visit our website (www.xerces.org) or call us at (503) 232-6639.

Through its pollinator conservation program, the Society offers practical advice and technical support on habitat management for native pollinator insects.

The University of California Berkeley collaborates with the Xerces Society on monitoring pollinator communities and pollination function at farm sites before and after restoration. University of California Berkeley conducts studies to calibrate the observational data collected by citizen scientists against the specimen-based data collected by scientists during standard surveys.

Section 1

GETTING STARTED

Bees are a greatly diverse and valuable group of animals, yet they remain generally overlooked and widely misunderstood. For most people, when they hear the word "bee," a single species comes to mind, the non-native European honey bee. However, in California, there are more than 1,500 species of wild native bees that are important for the pollination of crops and wild flowering plants. Roughly one third of crop production across the globe depends on insect pollinators, and about 75 percent of the earth's flowering plants rely on pollinators to reproduce.

In recent years, research has shown that when their habitat needs are met native bees can play a valuable role in pollinating crops. This is especially relevant today as the beekeeping industry continues to struggle with pests, diseases, and the phenomenon termed "Colony Collapse Disorder."

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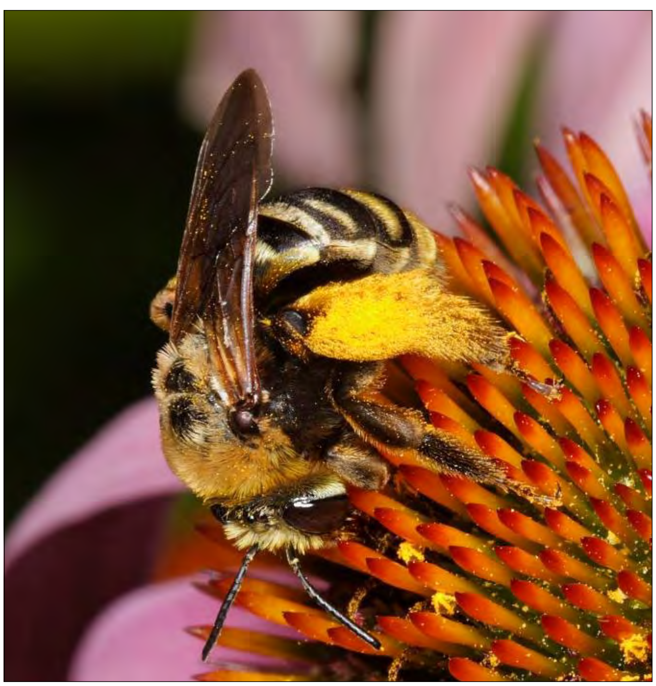
Bees are the most important group of pollinators in North America, responsible for pollinating crops and wildflowers.

Since 2003, the Xerces Society for Invertebrate Conservation and the University of California Berkeley have worked with partners, such as Audubon California's Landowner Stewardship Program, the Center for Land-Based Learning, the Natural Resources Conservation Service (NRCS), and landowners to improve native bee habitat in California's Central Valley and to increase pollination services provided by wild native bees to local farms. Since 2006, we have used professional, standard monitoring protocols to document how bee communities respond to restored pollinator habitat. To complement this monitoring, we also trained twenty citizen scientists to observe and identify morpho-groups of bee species (that is, groups of bee species that look similar). This citizen scientist data was then compared with data gathered by bee experts to determine how well they matched.. Early analysis of our paired data collection suggests that the coarse taxonomic diversity measured by citizen scientists correlates significantly with the more detailed, species specific data collected by bee experts.



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The pollen carried on flower-visiting insects is an essential link in the web of life.

There are an estimated 300 bee species in Yolo County, CA. Some of these species can only be identified by looking at the specimens under a microscope; there are only a handful of taxonomists in North America who can accurately identify all bee species to species level! However, by using the observation protocol and bee identification key found in this guide and by practicing observations with native bee experts, citizen scientists can learn to identify and monitor some of the most common bee species and "species-groups" (sets of species that look similar and, in some cases, are closely related species) found in Yolo County, CA.

Citizen Scientist Monitoring Protocol

The primary purpose of this monitoring protocol is to provide a method the public can use to collect data on bee diversity and abundance in a specific area, and to record changes in bee populations over time. This information may be useful if the goal is to increase the numbers and types of pollinators in an area by enhancing floral resources and/or nesting sites. Monitoring allows for the documentation of how these practices are affecting bee communities. Furthermore, if nearby crops need insect pollination to set fruit, monitoring bee visitation on these crops will give valuable information about the pollination service provided by local bee communities.

Monitoring Pollinators

Bee communities vary depending on the quality of habitat and where they are located within a given landscape. They also vary depending on the time of year and day when you sample. Documenting changes in bee communities using this protocol will allow you to assess the efficacy of best management practices aimed at increasing pollinator abundance and diversity. Best management practices may include enhancing floral resources and/or nesting sites, reducing tillage and reducing the non-target impact of pesticides. Alternatively, using this protocol to monitor pollinators in field crops or orchards can provide insights into which native species provide farmers with free pollination services.

To develop an accurate picture of how a bee community is changing, however, it is important to keep in mind the following two points:

- Because one of the primary goals of monitoring is to get comparative data about changes in bee diversity and abundance over time, consistency in monitoring protocol and technique is crucial.
- While this approach is geared towards those who are not experts in insect identification, accurate monitoring does require training and practice in identifying the broad groups of bees detailed in this guide.

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Monitoring of pollinators usually requires nothing more than careful observation of what the insects are doing and what they look like. By following the same procedure each time, you can build up a valuable record of which insects are most important.

Overview of Techniques and Guidelines

Standard monitoring techniques used by the research community to measure bee abundance and diversity include netting floral visitors off of flowers and using pan traps (bowls of soapy water). In both cases, specimens are collected, pinned, and then identified to species by a taxonomist. While these collection techniques provide the most refined data, they can be labor intensive and expensive. In addition, if they are not carried out properly, they can lead to over-collecting. Collecting observational data on floral

! It is sometimes difficult to tell flies, wasps, and bees apart. Furthermore, some bees look very similar to each other, but are in fact different species. Remember when identifying insects that **it is much better to identify bees at a coarse taxonomic level and describe them thoroughly** than to identify them inaccurately at a fine taxonomic level. When in doubt, identify only to the level you are confident at, and add notes to describe the insect.

visitors is an economical and effective alternative way to monitor bee populations. This protocol focuses on collecting observational data, however, it can be very useful to build a local reference collection of the species you find at flowers. This will help you learn the bees on site and will be a useful tool for training future observers.

The **Citizen Scientist Pollinator Monitoring Guide** can be used to collect consistent observational data on bee communities. Guidelines in this publication include information on: (1) setting up monitoring transects, (2) sample timing, (3) ensuring that weather conditions are appropriate for monitoring, (4) observing bees at flowers, (5) recording data, (6) analyzing data, and (7) identifying groups of floral visitors. A sample step-by-step monitoring protocol for use in the field is provided in Appendix A (page 33).

This monitoring tool is designed to be used after training with Xerces Society staff or professional scientists familiar with this monitoring guide. Training is important because although this guide groups bees, and a few other pollinators, into broad categories based on their appearance, identifying even these groups consistently and accurately takes some practice and feedback from those experienced with the methodology.

It also is important to note that the bee groups addressed in the identification guide are those found in the northern Central Valley of California from late spring to late summer. While these groups overlap significantly with the bees from other parts of California, you may come across species that do not fit into the categories found in this guide.

Setting up Transects in Monitoring Plots

In 2002, a group of bee biologists outlined a standardized way of collecting bee data and setting up monitoring plots (see http://online.sfsu.edu/~beeplot/), which has been adapted for the purposes of this citizen scientist monitoring.

Monitoring plots should be located within a relatively uniform habitat type, such as a meadow, hedgerow, or crop. If the area being monitoring is a large block, it is advisable to divide the area into linear transects that are at least 250 feet long (the longer the better), and 100 feet apart. Transects should be equally spaced throughout the study area. For areas less than two acres in size, a single transect through the middle of the site should be sufficient. For areas that are greater than 2 acres in size, two or three transects should be used for a total length between 600 and 750 feet (for example, three transects 200 to 250 feet long, or two transects 300 to 350 feet long).

For monitoring hedgerows or other linear habitats, transects should be at least 200 feet long, marked out prior to monitoring, and spaced evenly along the length of the hedgerow. If sampling both sides of a hedgerow, transects should have at least 25 feet between Wooden stakes and flagging tape can be used to mark the beginning and end of a transect.

Mapping a study area and transects within a study area is important because it will allow other researchers to monitor that area in the future. If possible, take GPS coordinates. If no GPS is available mark the study area and transects on a topographic map or aerial photo.

Sample Timing

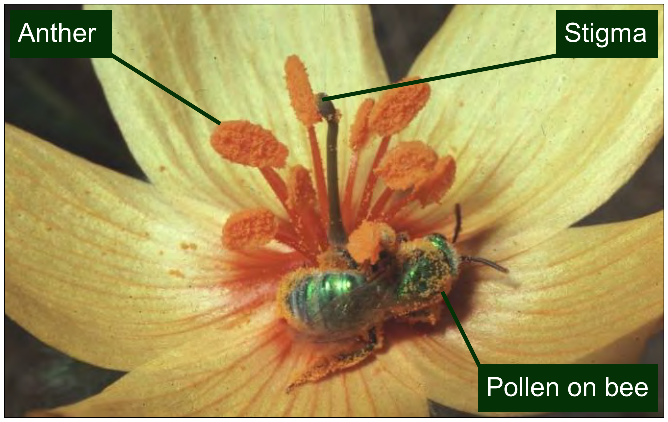
Bee communities vary greatly over time. While some bee groups appear consistently during every sample round, other groups are abundant only at certain times of the year. For this reason, it is important to monitor a study site at least three times throughout the course of the year, in late spring/early summer, mid summer, and late summer (the specific months for these seasons vary depending upon where you are in the California).

Many bee species only forage for pollen and nectar for a limited number of weeks every year. In addition, it can be difficult to get reliable data in smaller areas of habitat. For these reasons, it may be advisable to monitor a site monthly (or even more frequently), or sample an area twice in one day with at least a half hour between sampling.

Consistency is **very** important. Once dates for monitoring are selected, they should be repeated as closely as possible from one year to the next.

Appropriate Weather Conditions

Weather conditions strongly affect bee diversity and abundance. Bees do not like cold, windy, or overcast weather. To optimize bee sightings, conduct observations **only** when the temperature is at least 21 degrees Celsius (70º Fahrenheit), wind speeds are less than 2.5 meters/second (5.6 mph), and when there is enough sunlight to see your shadow. These conditions usually exist between 8am and 3pm. In order to monitor during optimal and consistent conditions, the time of day when monitoring occurs can be adjusted for the season and daily weather patterns.



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To determine wind speed, you can use an anemometer for a precise measure (available at some outdoor outfitters), or you can use the Beaufort Wind Scale to come up with an estimate. Winds of 0 to 1 mile per hour are considered "calm," with smoke rising vertically. Those of 1 to 3 miles per hour are described as "light air," with the direction shown by smoke drift, but not by wind vanes. A wind of 4 to 7 miles per hour is described as a "light breeze," in which you can feel the wind on your face, leaves rustle, and ordinary wind vanes move. At 8 to 12 miles per hour—too fast to be sampling for bees—leaves and small twigs will be in constant motion and a light flag extended.

How to Observe Bees at Flowers

Before you begin monitoring it is important to know how to make observations and how to identify floral visitors. Much of this guide focuses on the latter, but it is important to keep the following points in mind when collecting observational data on floral visitors:

Only collect data on insects visiting the reproductive parts of the flower: These insects likely will be collecting either pollen or nectar. It can be difficult to observe this on very small flowers. In this case, observe the floral visitor's behavior. During the sampling period, you should not identify or make notes on animals sitting on petals, leaves, stems, etc., or visitors flying around the area.

Look at all flower types: Bees may visit flowers that are less noticeable to people – such as flowers that are quite small or green. They may also forage in deep flowers. For example, in Yolo County, many small bees forage in the center of the cone-shaped flowers of bindweed (*Convolvulus arvensis*; also known as morning glory), a crawling plant that grows on the ground. Avoid focusing on only one or a few flower types.

Be careful not to disturb insects visiting flowers before you get a chance to observe them well: Avoid sudden movements and do not stand too close to the flower you are observing. Also, insects respond to shadows passing overhead by moving away; walk so that your shadow trails you, rather than advances in front of you.

Observe and identify insects as best you can and only to a level at which you are confident: Bee groups can be difficult to tell apart. Even noting whether a visitor is a honey bee, native bee, fly, wasp or butterfly is useful information. If you are particularly interested in monitoring native bees, it will be important for you to distinguish, at minimum, honey bees from native bees.

<u>Be patient</u>: If you are monitoring a newly established planted area be aware that it may take a few years, while the plants get established, to see an increase in pollinator (or flower-visitor) activity.

Recording Data

This monitoring protocol is designed for a two-person observer team: one to make observations and one to record those observations. Before you start collecting data, record all information asked for on the datasheet found at the back of this guide (pages 35 and 36, please photocopy the datasheet as required; we recommend doing double-sided copies). This information includes the location, time, and date, as well as weather conditions before a monitoring period.

Also included at the top of the datasheet is a calculation for how long it should take to walk a transect. Citizen scientists should pace themselves so that they move along a transect at an average rate of about 10 feet per minute. For example, a 250 feet transect should take about 25 minutes to monitor. Floral density may affect the pace of monitoring within a transect. For example, although the average recommended pace is 10 feet per minute, observers may slow the pace in portions of a transect with particularly high floral density, and increase it where blooming plants are absent.

Note the start time and end time for walking the transect and identifying bees. Use a timer to help keep track of how quickly you are moving through the site (and how much time you have left). Do not stop the timer when you are looking at the floral visitors you are identifying and counting.

The goal here is to establish a standard sampling duration for each transect based on the size of the site (transect). This sample duration stays the same for each site and for each sample period and year, regardless of floral or bee density, in order to standardize a consistent level of effort. This could mean that the observers won't cover the whole transect (although, every effort should be made to cover the whole designated area at least once), or may need to backtrack if they complete the transect before the allotted time is up.

The bee monitoring data that is collected, as outlined in the data sheets on pages 35 and 36, should include: an identification of each floral visitor (only to the level which the observer is confident), a description of the insect or bee group, and the number of times individuals of this insect or bee group are seen during the monitoring period. The observer dictates the floral visitors and their descriptions, while the observer's partner records this information on the datasheet.

! In order to analyze how bee communities change over time it is important to standardize the monitoring protocol, sampling effort, and weather conditions. Specifically, monitoring should occur at roughly the same time every year, for the same amount of time, over the same area, and under similar conditions using a standardized protocol. Once a protocol has been established for a site, it should be clearly written out so that the it may be referenced in future years (as a reminder) or replicated by a different trained observer.

Additional Data to Collect

It also is valuable to collect data on plants that are visited by bees and other pollinators. This information will be useful for improving your understanding of which plants are important over time because the most important plant resources used by the bees may change depending upon the time of day, or from year to year and place to place. For restoration sites, the lists of plants that were planted on site should be available. If not, then you will need to bring plant identification guides with you. Keep in mind that it is important to document plants that are not being visited, as well as those that are.

Plotting Your Data

In order to draw meaningful conclusions about the effects of habitat on bee abundance and diversity, data should be collected in a consistent manner over several years. To determine changes in abundance over time, tally the number of individual specimens observed during each monitoring event. These numbers could be averaged for each year (for example, combine results from the late spring, summer, and late summer sampling periods into a single figure) and plotted on a graph or table to show change between years (for example, see Table 1(a) and Figure 1; page 8). Alternatively, you could total the number of individual specimens observed during each monitoring event or period, and look at each sampling period individually (for example, look at changes in the total number of bees observed during the mid-summer sampling from year 1 to year 2, etc.).

Similarly, to calculate a measure of diversity for each sample period or year, you could tally the total number of the eleven different bee groups represented in the CSM Monitoring Guide (e.g. striped sweat bee, hairy leg bee, tiny dark bee, etc.). Once again, the total number of these different groups could be plotted to record changes over time, either comparing sample periods from year to year, or the total number of groups observed across all sample periods for each year (for example, see Table 1(b) and Figure 1, below).

It is important to note that bee populations can vary greatly from season to season as well as from year to year, even in areas where the habitat is essentially unaltered. Thus, numbers of species represented, or even of individual specimens counted within study areas could be somewhat inconsistent. It is for this reason that monitoring is best done for many years in a row; the longer samples are collected, the more meaningful the results. In order to draw any substantial conclusions, sites should be monitored for a minimum of three years, and ideally five. In areas where specific habitat and management improvements have been made to attract and protect pollinators, there should be an upward trend in both bee abundance and diversity over the course of several years. If possible, when habitat improvements are planned, it is useful to acquire data on the bee community on site before enhancing the habitat.

Table 1. Example data spreadsheets

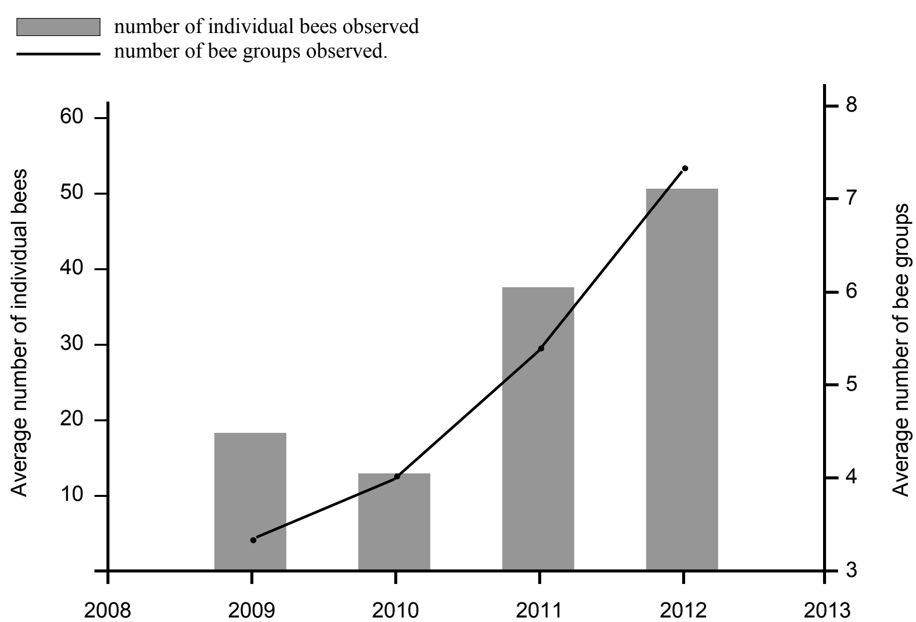
(a) number of individual bees observed

# bees	Late Spring	Mid-summer	Late Summer	Averages
2009	Date: 5/1	Date: 6/27	Date: 8/9	18.7
	# bees: 4	# bees: 14	# bees: 28	
2010	Date: 5/3	Date: 7/4	Date: 8/8	13
	# bees: 8	# bees: 16	# bees: 15	
2011	Date: 4/30	Date: 6/30	Date: 8/11	35.7
	# bees: 22	# bees: 43	# bees: 42	
2012	Date: 5/6	Date: 6/29	Date: 8/14	51
	# bees: 28	# bees: 58	# bees: 67	

(b) number of bee groups observed.

# groups	Late Spring	Mid-summer	Late Summer	Averages
2009	Date: 5/1	Date: 6/27	Date: 8/9	3.3
	# grps: 2	# grps: 3	# grps: 5	
2010	Date: 5/3	Date: 7/4	Date: 8/8	4
	# grps: 4	# grps: 3	# grps: 5	
2011	Date: 4/30	Date: 6/30	Date: 8/11	5.3
	# grps: 4	# grps: 6	# grps: 6	
2012	Date: 6/6	Date: 6/29	Date: 8/14	7.3
	# grps: 6	# grps: 9	# grps: 7	

Figure 1. Example graph showing change over years



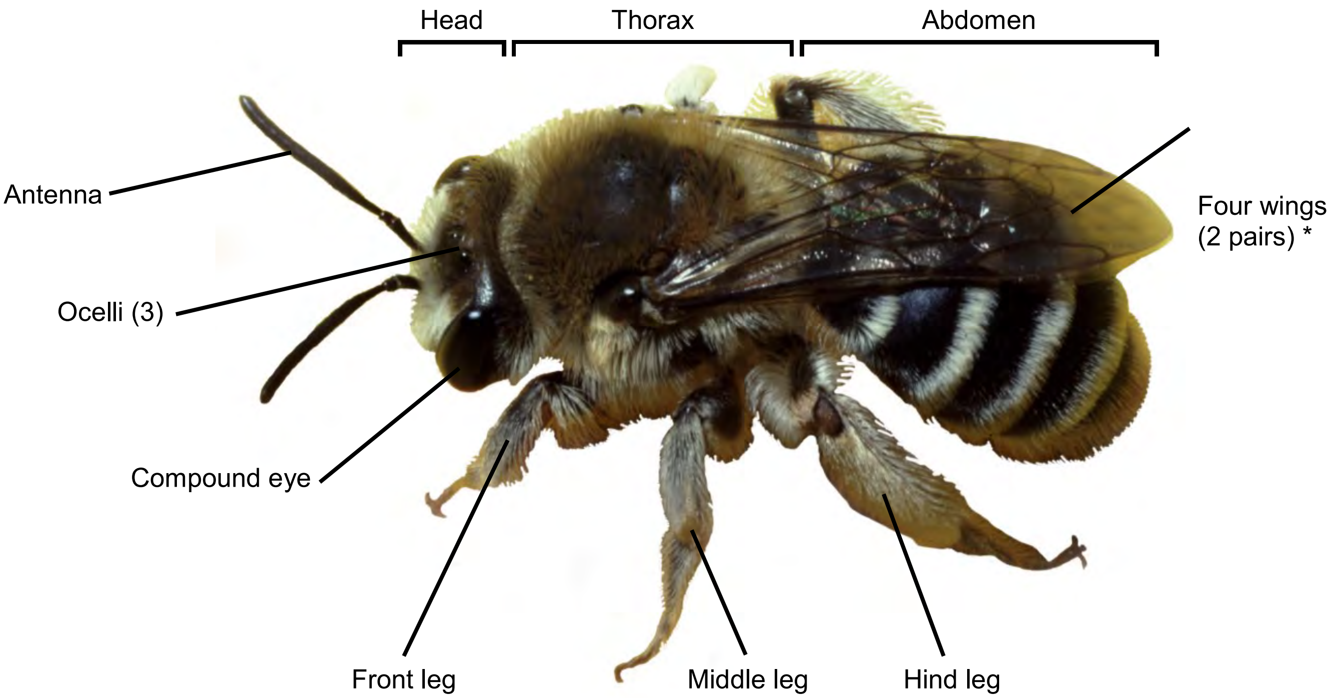
Section 2

Identifying Floral Visitors

Bees, in general, have evolved to be the most efficient pollen transporters. However, flies, wasps, butterflies & moths, beetles, bugs, and birds that visit flowers have the potential to pollinate as well. For this reason it is important to note *all* floral visitors.

Distinguishing butterflies, moths, or spiders from bees is simple. Separating bees from wasps or flies—especially those that mimic bees—can be harder. The following pages give more information on how to identify the principal groups of pollinators and key characteristics to look for when identifying specific bee groups.

But first, let's focus on bees. To help you get to know a bee, take a look at the diagram below, on which the major body parts have been labeled. On the next page you will find more about the key characteristics of bees.



* It can be difficult to see all four wings because sometime the wings are folded on top of each other.

!

A Note About Stings

When working around bees (and wasps) there is always a risk of getting stung. Most bees will not sting unless they are provoked, which is very difficult to do when they are at flowers. Most wild native bees are far less defensive than the European honey bee. We will be observing both wild bees and honey bees. Should you be stung by <u>any</u> bee (or wasp) while out in the field, please let a researcher know that you were stung and what type of bee (or wasp) stung you. Most people have mild reactions to bee stings and exhibit a reaction only at the site of the sting. However, it is important to monitor yourself after a sting for signs of a more severe reaction. Symptoms of a serious reaction include swelling elsewhere on the body, vomiting, dizziness, hoarseness, thickened speech, or difficulty breathing, and should receive prompt medical care from a physician.

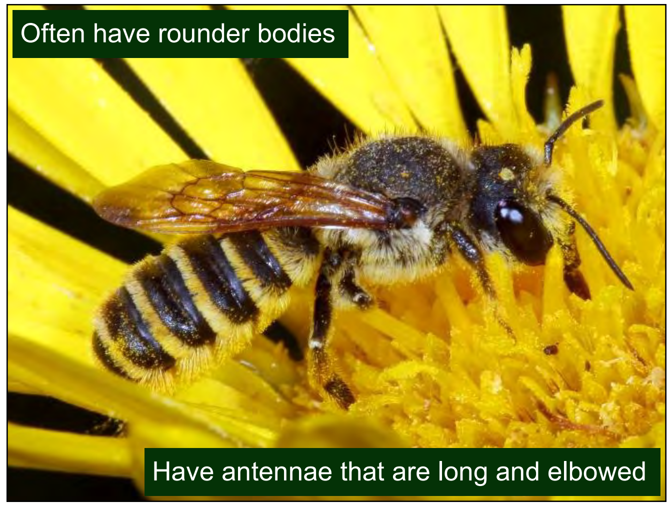
Bees

Key characteristics:

- Bees often have **rounder bodies** than wasps and flies.
- Bees have **antennae that are long and elbowed**
- Most bees are **hairy**, especially on their legs and/or on their abdomen.
- Female bees can **carry large loads of pollen**, either on their legs or on their abdomen.
- Bees have **four wings** (but it can be difficult to see all four).

Size: can be small, medium, or large.
Color: can be black, brown, orange, dull silver, grey, metallic, blue, green, and sometimes yellow.
Stripes: can be striped.

Bees are an incredibly diverse group of insects. Some look very “bee-like” (hairy with black-and-yellow stripes), but many are bright colors.



! Male bees are often less hairy than female bees, often have longer antennae, and lack pollen carrying structures. Females usually have specialized structures on their hind legs or abdomen for carrying pollen.

Non-Bees: A Quick Reference

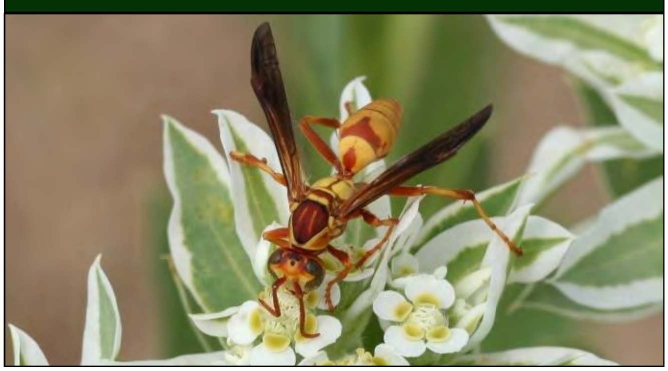
Bird

Fly

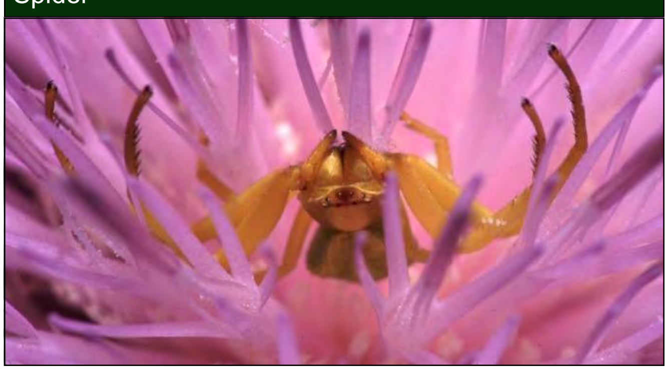
More details on page 12.

Wasp

More details on page 13.



Spider



Butterfly & Moth

Other (beetle, bug, etc.)

Flies vs. Bees

Key characteristics:

- Flies often **have short thick antennae** (sometimes difficult to see).
- Flies **often have large eyes near the front of their head**.
- Flies only have **two wings (one pair)**.
- Flies can be hairy, but are **usually not very hairy**.
- Flies **can hover** (most bees are not able to hover).
- Flies **do not carry large loads of pollen** although some grains may stick to their bodies.

Size: can be small, medium, or large.
Color: can be black, yellow, blue, or green.
Stripes: can have stripes (some look like bees!).

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© David Inouye

Some flies can be very bee-like in appearance. This is a drone fly (*Eristalis tenax*), a honey bee mimic, and like the honey bee, an introduced species from Europe.

© Joseph Berger; Bugwood.org

© Mace Vaughan

Wasps vs. Bees

Key characteristics:

- Wasps, like bees, have **four wings** (two pairs; often folded lengthways), but it can be hard to see them all.
- Wasps **look "tougher"**—they can have **narrower bodies** and a **very pinched abdomen** (more obvious than in bees).
- Wasps can have **patterns on their exoskeleton** (bee markings are usually colored hairs).
- Wasps are **not hairy**.
- Wasps **do not carry pollen loads**, although some pollen grains may stick to their bodies.

Size: can be small, medium, or large.
Color: can be black, red, yellow, blue, brown, or green.
Stripes: can have stripes (can look a lot like a bee!).

Wasps are often described as appearing "more tough" or "more rugged" than bees.

Section 3
Understanding Bees

This section describes the key characteristics that identify different bees. You can then use these to help you navigate the key found on page 21.

If you see that a floral visitor is carrying loads of pollen on its hind legs or abdomen, this visitor is likely a bee. Female bees collect pollen from flowers to bring back to their nests, where they use it to feed their offspring. For this reason, they have evolved to be very efficient pollen transporters. All bees have branched ("feathery") hairs to which pollen easily sticks. In addition, bees also have dense hairy patches or other structures for storing pollen for transportation. Depending on the family, these hairs will be on the hind legs or the underside of the abdomen. Some bees, such as honey bees and bumble bees, will add nectar to pollen that they have collected so that it is moist. This moist pollen is then packed onto "pollen baskets," flat areas edged with hairs on the middle part of the hind legs. However, bees such as cuckoo bees (see page 32), who do not construct their own nests, lack pollen carrying structures altogether.

To confuse things slightly, males do not collect and transport pollen, and so are usually less hairy than females, and in some species both males and females have few hairs.

Hairs

Key characteristics:
- Is the bee **hairy**?
- If so, **where**?

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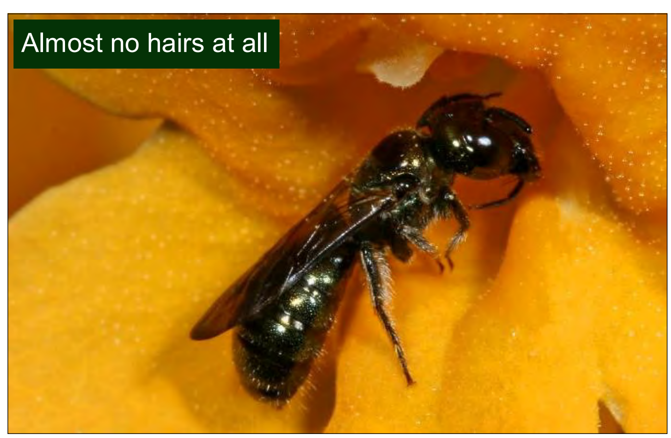

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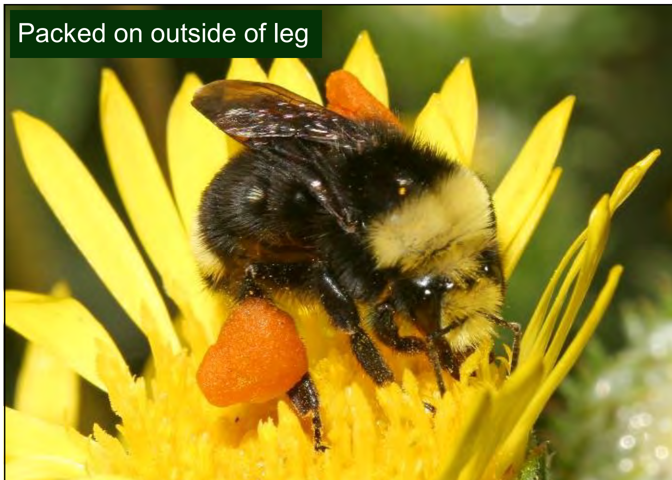
Pollen

Key characteristics:

- Does the bee have **pollen** on its body?
- If so, **where**?
- Does the pollen look **moist or dry**?


Packed on outside of leg


All around its leg


On the underside of its abdomen


All over its legs and base of thorax


Moist pollen


Dry pollen

Size and Shape

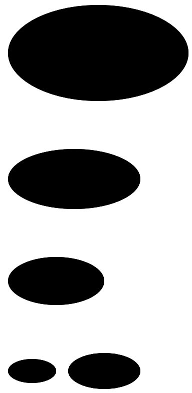
- What **size** is the bee?

Extra-large

Large

Medium

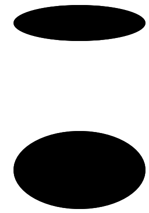
Small



- What **shape** is the bee?

Narrow

Robust



© Stephen L. Buchmann

Little and large: *Perdita minima*, the smallest bee in North America, placed on the face of one of the largest, *Xylocopa varipuncta*.

© Mace Vaughan

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Color

Key characteristics:

- What **color** is the bee?
- Are the head, thorax, and/or abdomen **different colors**?
- Is it **metallic**?

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Stripes

Key characteristics:

- Does the bee have **stripes on its body**?
- If so, **where**?

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Antennae

Key characteristic:

- Does the bee have **long or short antennae**, relative to the size of its body?

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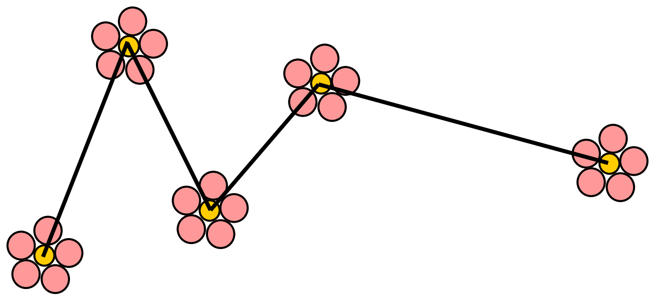
Flight

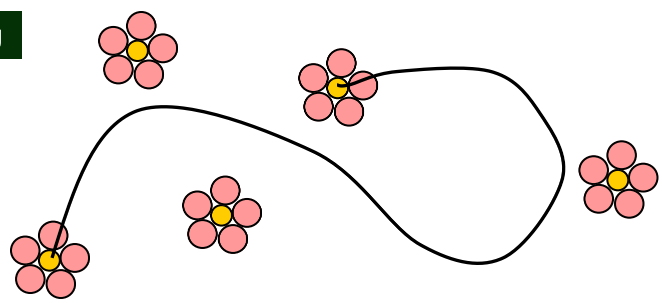
Key characteristics:

- Does the bee fly **fast or slow**?
- Is it **noisy or quiet** when it flies?
- **What kind of movements** does it make when it flies?

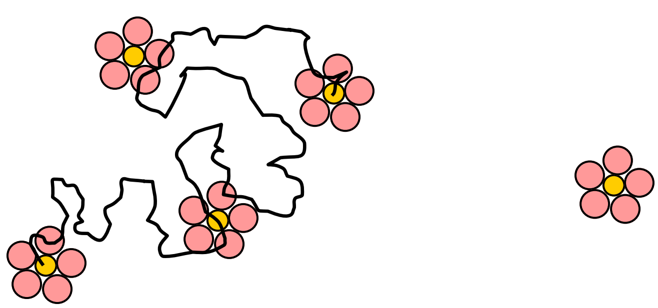
Methodical



Smooth or hopping



Erratic



Section 4

A Guide to the Different Groups of Bees

There are more than 1,500 species of bees in California. In Yolo County there are an estimated 300 bee species, of which about 60 species visit crops. This guide will help you identify some of the different bee groups. The photos on this page illustrate some of the diversity of these bees.

Remember, this key is not an exhaustive list, so if you observe a bee that is not in the key, note the bee as "Other bee" and describe the bee thoroughly. Even if you can't identify the bee precisely, it is important to document that it was observed.

In particular, it is important to distinguish the honey bees, which are non-native, from the native bees. Whenever possible, attempt at minimum to distinguish honey bees from the rest of the bee categories. Therefore, study the "honey bee" page carefully.

Key characteristics to keep in mind when observing bees (see previous pages for details of each):

- Hairs?
- Pollen?
- Size and shape?
- Color?
- Stripes?
- Antennae?
- Flight pattern?


Bumble bee

© Rollin Coville


Honey bee

© James Cane


Small carpenter bees

© Edward S. Ross


Metallic sweat bee

© Rollin Coville


Leafcutter bee

© Edward S. Ross

Key to Identifying Floral Visitors

Non-Bee
- Bird (p. 11)
- Butterfly or Moth (p. 11)
- Fly (p. 12)
- Wasp (p. 13)
- Spider (p. 11)
- Other—bug/beetle, etc. (p. 11)

Bee
- Little or no hair on underside of abdomen
  - Honey Bee (p. 22)
  - Bumble Bee
    - Black Face (p. 23)
    - Yellow Face (p. 23)
    - Orange Tip (p. 23)
    - Yellow Body (p. 23)
    - Four Stripes (p. 23)
  - Large Carpenter Bee (p. 24)
  - Hairy Leg Bee (p. 25)
  - Green Sweat Bee (p. 26)
  - Striped Sweat Bee
    - Small (p. 27)
    - Medium (p. 27)
  - Small Dark Bee
    - Rounded Tip (p. 28)
    - Shield (Pointed) Tip (p. 28)
    - Yellow Face & Wasp-like (p. 28)
- Thick pollen-carrying hair on underside of abdomen
  - Striped Hairy Belly Bee
    - Small (p. 29)
    - Medium (p. 29)
  - Metallic Hairy Belly Bee
    - Blue/Black (p. 30)
    - Green (p. 30)
- Cuckoo Bee
  - Red Abdomen (p. 31)
  - Large (p. 31)
  - Small (p. 31)

! **NOTE:** Identify bees to the most specific group possible. For example, if you do not know what type of bee you see, but you know that it is not a honey bee, note only that "it is not a honey bee." In some cases (e.g., bumble bees) it will be possible to distinguish species within a bee group.

Honey Bee

For most people, it is the honey bee that comes to mind when they hear the word “bee.”

Key characteristics:

- Size: medium to large.
- Orange-brown to nearly black.
- Stripes on abdomen.
- Enlarged, flattened plates on hind legs.
- Fuzzy thorax.
- Carries moist pollen in clumps on hind legs.
- Often flies methodically from flower to flower.
- Makes a buzzing sound when flying.

Approximate size range: 

Important:
During monitoring, distinguishing between honey bees and the rest of the bee categories is the most important observation you can make.

Caution:
There are some flies that mimic honey bees: look for small antennae, big fly eyes, and skinny hind legs to tell the difference. See images of flies on page 12.

Color variation: dark to pale

Striped abdomen

Enlarged, flattened plates on hind leg shaped to carry pollen

Fuzzy tho-

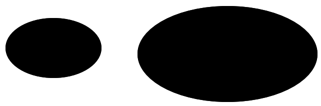
Moist clumps of pollen on upper hind leg

Bumble Bee

Key characteristics:

- Size: medium to very large, robust body shape (workers smaller than queens).
- Mostly black, with some yellow stripes.
- Entire body fuzzy.
- Has flattened plate on upper hind leg for carrying moist clumps of pollen.
- Make a low buzzing sound when flying.

Approximate size range:



Four Stripes

© Rollin Coville

Black Face

© Edward S. Ross

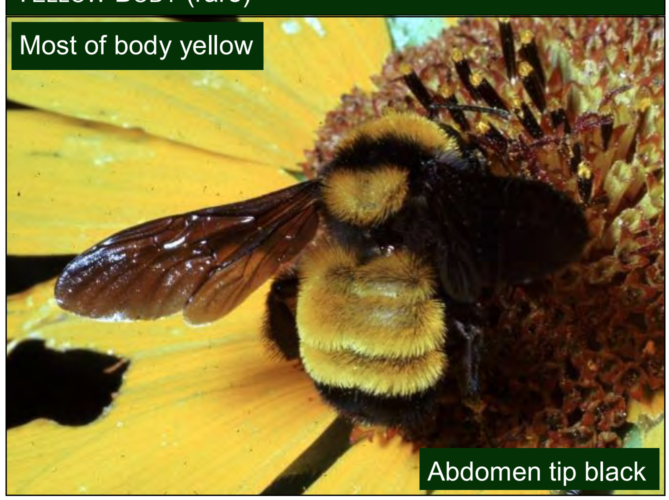
Yellow Face

© Rod Gilbert

Orange Tip

© Tom Greer

Yellow Body (rare)



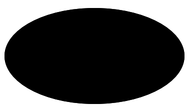
© Edward S. Ross

Large Carpenter Bee

Large carpenter bees look very similar to bumble bees, but they are shinier (less hairy), especially on the abdomen.

Key characteristics:

- Size: very large.
- Shiny black abdomen and/or thorax (may have some hair on it).
- Has brush of hair on hind leg for carrying pollen.
- Usually black or dark blue (sometimes dusted with pollen to give a creamish color), males sometimes brownish.
- Often found near urban areas.
- Territorial (may buzz by your head).

Approximate size: 

Hairy Leg Bee

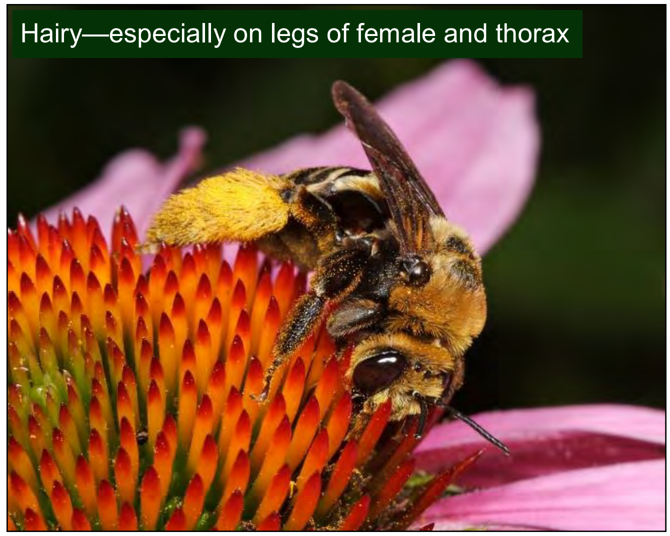
Key characteristics:

- Size: medium to large.
- Often hairy—especially on thorax—with short, dense, velvety hair.
- Collects dry pollen in brush of hair on leg, but often has pollen on whole body.
- Can fly fast (usually in smooth motions that almost look like they are tracing a figure 8) and can visit flowers rapidly.
- Some males can have long antennae and may have striped abdomen.

Approximate size range: 

Important:
Note key characteristics for this group when you see them visiting flowers (e.g., pollen, hairy, size/shape, color, stripes, antennae, and flight).

The legs of males will not be as hairy as the legs of females because males do not transport pollen. Additionally, in general, males often have much longer antennae than females.


Hairy—especially on legs of female and thorax


Stripes on abdomen

Collect dry pollen—can be all over body


Can have very long antennae


Can have short antennae

Green Sweat Bee

Key characteristics:

- Size: medium.
- Metallic green (sometimes with striped abdomen).
- Narrow bodies.
- Relatively fast flying.

Approximate size:

Note:
Some Metallic Hairy Belly Bees and wasps can be green. First look to see whether the green visitor is a bee or not, and then look to see where it is carrying pollen or where it is hairy. (Sweat Bees carry pollen on their hind legs; Metallic Hairy Belly Bees carry pollen on the underside of their abdomens.)


Metallic green; may be infused with gold


Brush of hair on hind legs; may be loaded with pollen


Males can have yellow-and-brown striped abdomen

Striped Sweat Bee

Key characteristics:

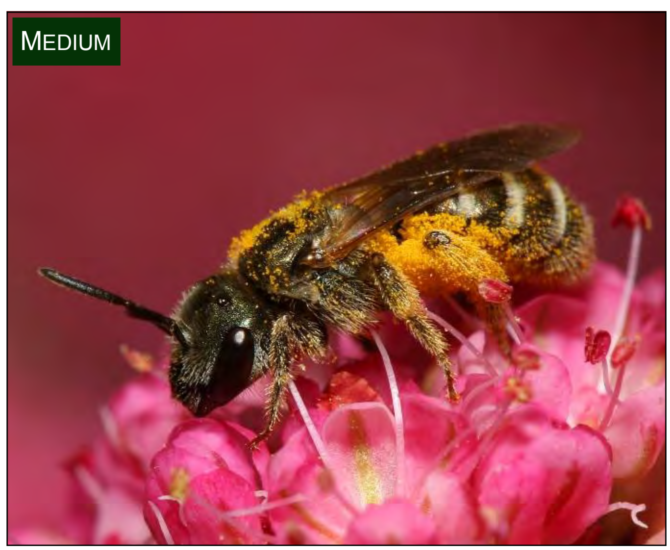
- Size: small to medium.
- Narrow bodies.
- Typically appear black
- Stripes on abdomen may be creamy to dark gray.
- Stripes may be faint.
- Brush of hair on hind legs, sometimes loaded with pollen, but abdomen may look smooth.
- May crawl around the base of flowers or inside flowers.
- Can move fast—some with jagged movements.

Approximate size range:

© Rollin Coville

© Derrick Ditchburn; www.dereilanatureinn.ca

© USDA-ARS/Scott Bauer



© Rollin Coville

Small Dark Bee

Key characteristics:

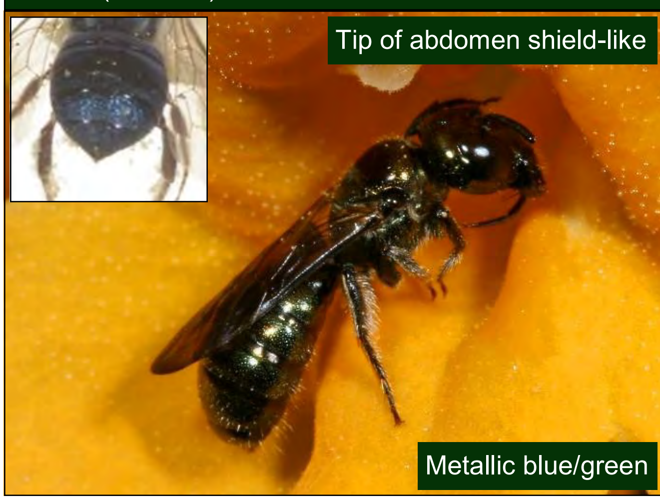
- Size: small.
- Narrow bodies.
- Often black, metallic green-grey, metallic blue, and/or brown.
- Faint stripes, if any.
- May swarm near flowers.
- Often crawl deep into flowers.
- Brushes of hair on hind leg, sometimes with pollen.
- Sometimes white or yellow markings on face.
- Can move fast—some with jagged movements.

Approximate size: 

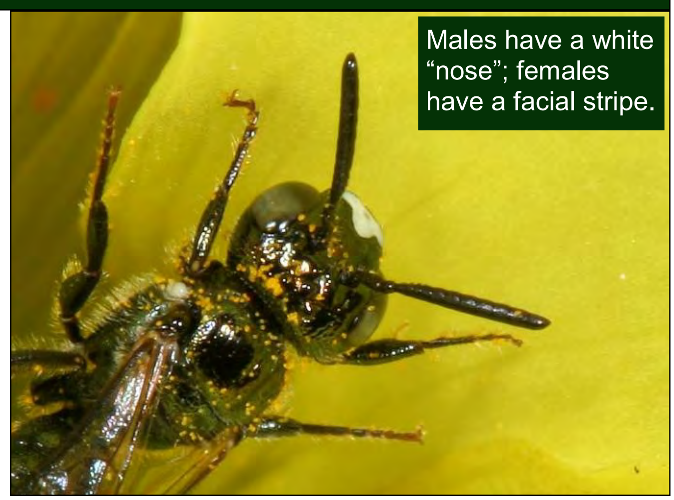
Rounded Tip

© Rollin Coville (Inset: John Pascarella; http://chiron.valdosta.edu)

Shield (Pointed) Tip

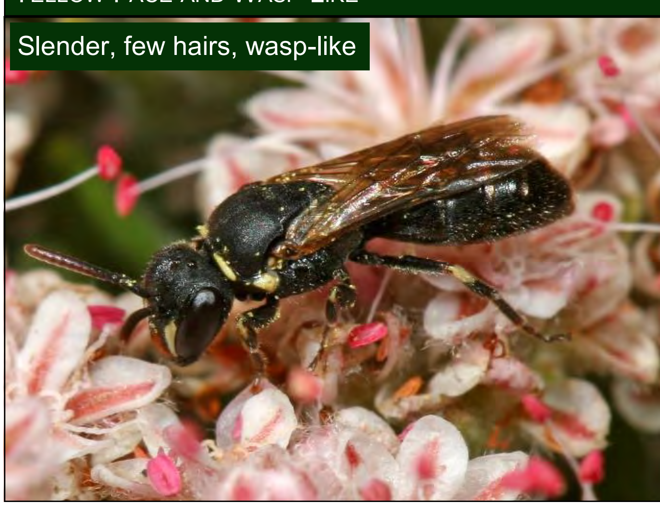


© Rollin Coville (Inset: Georgia Uni. of Georgia; www.discoverlife.org)



© Rollin Coville

Yellow Face and Wasp-Like



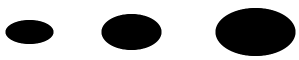
© Rollin Coville

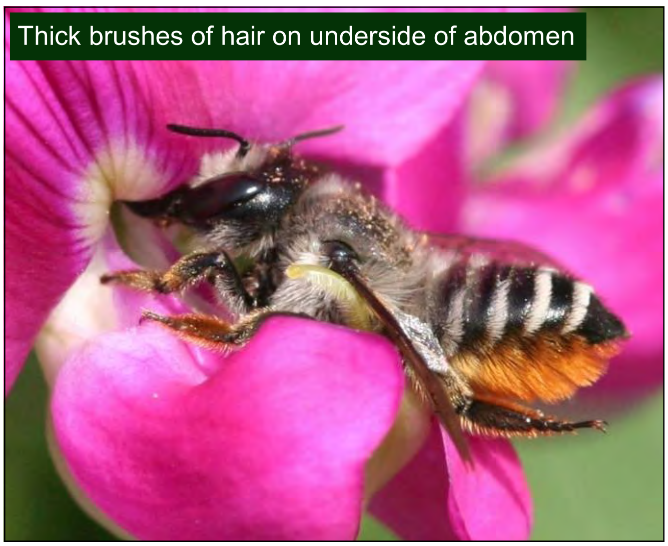
© Tom Murray; www.pbase.com/tmurray74

Striped Hairy Belly Bee

Key characteristics:

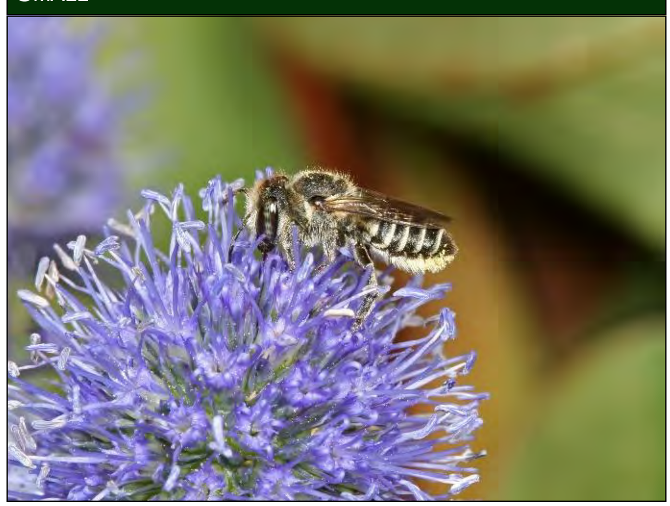
- Size: mostly small to medium, but a few are large.
- Black with white/silvery hairs.
- Brushes of hair on underside of abdomen.
- Transports pollen using hair on underside of abdomen.
- Often have white bands on abdomen.
- When visiting flowers, often elevate abdomen, revealing pollen underneath.

Approximate size range: 



MEDIUM

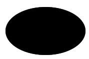
SMALL



Metallic Hairy Belly Bee (Blue or Green)

Key characteristics:

- Observed in spring and early summer.
- Size: small to medium.
- Stout bodies.
- Often metallic green, blue, or bluish black.
- Brushes of hair beneath abdomen—no prominent hair bands, may have pollen.

Approximate size: 

METALLIC BLUE

Stout, round body

© USDA-ARS/Jack Dykinga

METALLIC GREEN

Color can be very bright

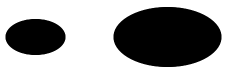
Brushes of hair (or pollen load) on abdomen

© Mace Vaughan

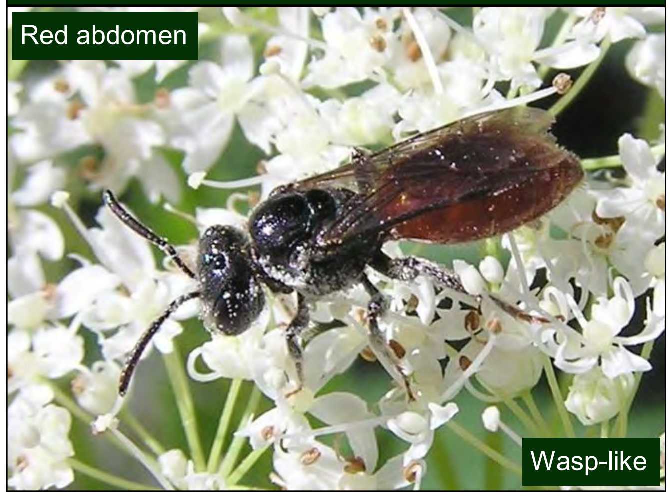
Cuckoo Bee

Key characteristics:

- Size: small to large.
- Not very hairy.
- Can have wasp-like markings made from short, thick hairs.
- Can have red legs or black legs.
- Body black, cream, red, or yellowish.
- Lack pollen carrying structures

Approximate size: 

Red Abdomen



Small

Large

Appendix A

MONITORING PROTOCOL AND DATASHEET

This sample bee monitoring protocol can be used to collect observational data on the abundance and diversity of native bees, and is designed for observers working in pairs.

Materials Required

- Identification and monitoring guides (*Citizen Science Pollinator Monitoring Guide* and the companion *Pocket Guide*)
- Clipboard
- Pencil
- Datasheet(s)
- Permits (if necessary)
- Timer
- Thermometer
- Wind meter (optional)
- Sunscreen
- Hat
- Water
- First aid kit (including an Epipen or other appropriate medicine if allergic to bees)
- **Optional**: plant list for the site and/or plant identification guide

To set up transect, bring:

- Measuring tape (100 or 150 foot)
- Flagging to mark the start and end points for transects
- Aerial photo or map to document location of transect
- **Optional**: GPS to record the start and end points of the transect

Example of Applying the Protocol

Note that this is an example and the exact timing may vary depending upon weather and the size of the site being monitored.

Setting up a site

Prior to conducting site monitoring, transects need to be established and the length between start and end points needs to be measured. Also, it is important to map the site and/or take GPS coordinates. If no GPS is available, the transect(s) should be marked on a topographic map or aerial photo.

Monitoring a site

9:00am: <u>Arrive at site</u>

1. Set up thermometer in the shade, and fill out the site/date information in the data sheet.

9:10am: <u>Record start weather data and determine sample duration</u>

1. Shade temperature

    Should be greater than 21C (70F)

2. Wind speed

    Average wind speed over one minute (at shoulder height, facing the wind) should be less than 2.5 m/s (5.6 mph)

3. Cloud cover

    Clear = clouds rarely/never cover sun;
    Partly cloudy = clouds cover sun sometimes;
    Bright overcast = even haze/clouds, but sun and/or light shadows are visible;
    Overcast = more overcast than bright overcast; no shadows are cast.
    <u>Note: Do not sample in overcast, rainy, or windy conditions.</u>

4. Sample duration

    To determine the number of minutes you need to sample your site divide the total length (in feet) of the transect(s) by ten.
    Record this number of minutes on the top of the data sheet.

9:20am – 10:20am: <u>Observations</u>

Note: This example is based on a 600 foot long transect sampled during a citizen scientist training session.

During training, the observer and recorder work together to collect observational data for a total of one hour. The observer and recorder should cover the study area as evenly as possible.

1. Set timer to 60 minutes. Note start time and then start timer

2. Begin walking the transect through your study area. Pace yourself. You should try and cover the study area as evenly as possible—it is important not to rush through the area, but it is also important to keep moving (i.e., do not spend more than a couple of observational minutes at any flower or group of flowers). It is also important to be as consistent as possible each time you visit a site so that you collect data with the same level of effort. This will allow you to more reliably compare data from year to year.

3. When you see an animal visiting the reproductive parts of a flower:

- Observe, identify and note the animal(s) as best you can until you are satisfied with your identification or until the visitor flies away. The recorder should note your observations.
- If you see more than one floral visitor on a single flower, first note the number of visitors and then identify them.

4. Begin walking again and continue with your observations until your sampling time is finished.

5. Note end time.

10:20am: Record end weather data
See above.

10:25am: Record any additional notes about the site
After you have finished collecting data on the bees, note each of the flower species that are in bloom and whether they have floral visitors. You can also record unique insects seen at the site, the intensity of visitation to specific flowers, vigor of the planting, needs for site maintenance, observer contact information, etc.

DURING YOUR OBSERVATION

- Only identify and make notes on the animals visiting the reproductive parts of the flower. Do not identify or make notes on animals sitting on petals, leaves, stems, etc., or visitors flying around the area.
- Be careful not to disturb insects visiting flowers before you get a chance to observe them well. Avoid sudden movements. Insects respond to a shadow passing overhead by moving away; walk so that your shadow trails you, rather than advances in front of you. Also, do not stand too close to the flower you are observing.
- If you have walked through the entire study area before the allotted time has expired (in the case of this example, 60 minutes for the whole transect), stop the stop watch and quickly return to the beginning of the transect and resample the transect until time runs out.
- Bee species can be difficult to tell apart. If you are particularly interested in monitoring the native bees on your property, it will be important for you to distinguish, at minimum, honey bees from native bees.

Pollinator Monitoring Datasheet

Instructions: 1. . Fill out top part of data sheet; 2. Set timer (1 minute for each ten feet), and when ready hit start; 3. Note any floral visitors you see and identify to your confidence level; 4. Keep walking until the time is up; 5. Fill out remainder of top of datasheet; and 6. make additional notes abou the site.

Site Name:	**Date:** / /	**Observer:**	**Data recorder:**

Observation start time:	**Weather at start**	Shade temp (°C):	Wind (m/s):	Sky: clear/partly cloudy/bright overcast
Observation end time:	**Weather at end**	Shade temp (°C):	Wind (m/s):	Sky: clear/partly cloudy/bright overcast

Visitor Categories:

Type = Honey Bee, Other Bee, Fly, Wasp, Moth/Butterfly, Spider, Beetle, Bug, Bird, Ant, Other, UFI (unidentified flying insect)

Bee Groups

Honey bee = **HB**
Bumble bee = **Bumble** ((black face/yellow face/orange tip/four stripe/yellow body)
Carpenter = **Carpenter**
Hairy Leg Bee = **HLB**
Green Sweat Bee = **Green Sweat Bee**

Striped Sweat Bee = **SSB** (small/medium)
Small Dark Bee = **SDB** (Rounded tip/shield tip/yellow face and wasp-like)
Striped Hairy Belly Bee = **SHBB** (small/medium)
Metallic Hairy Belly Bee = **MHBB** (blue/black /green)
Cuckoo Bee = **Cuckoo** (red abdomen/small/large)

Observation

Important: Remember to look out for flowers, stand so that you do not cast a shadow, and only ID floral visitors to the level at which you are confident in your identification.

	Citizen Scientist Floral Visitor ID	Description	Number of times identified floral visitors observed
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Continue over page for additional Observations and for Notes and Comments.

Visitor Categories:

Type = Honey Bee, Other Bee, Fly, Wasp, Moth/Butterfly, Spider, Beetle, Bug, Bird, Ant, Other, UFI (unidentified flying insect)

Bee Groups

Honey bee = **HB**
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Cuckoo Bee = **Cuckoo** (red abdomen/small/large)

Observation

Important: Remember to look out for flowers, stand so that you do not cast a shadow, and only ID floral visitors to the level at which you are confident in your identification.

11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Notes and Comments

Appendix B

NAMES OF BEES IN THIS GUIDE

BEE GROUP	COMMON NAME	SCIENTIFIC NAME	FAMILY
Honey Bee	Honey Bee	*Apis mellifera*	Apidae
Bumble Bee			
Black Face	California Bumble Bee	*Bombus californicus*	Apidae
Yellow Face	Yellow-faced Bumble Bee	*Bombus vosnesenskii*	Apidae
Orange Tip	Crotchii Bumble Bee	*Bombus crotchii*	Apidae
Yellow Body	Sonoran Bumble Bee	*Bombus sonorus*	Apidae
Four stripes	Black Tip Bumble Bee	*Bombus melanopygus*	Apidae
Large Carpenter Bee	Carpenter Bee	*Xylocopa* sp.	Apidae
Hairy Leg Bee	Long-horned Bee, Sun-flower Bee, Flower Bee, Striped Bee, Digger Bee	*Anthophora* sp. *Diadasia* sp. *Mellisodes* sp. *Svastra* sp. *Eucera* sp.	Apidae Apidae Apidae Apidae Apidae
Green Sweat Bee	Green Sweat Bee	*Agapostemon* sp.	Halictidae
Striped Sweat Bee			
Small	Small Sweat bee	*Halictus tripartitus* *Lasioglossum* (*Evylaeus*) sp.	Halictidae Halictidae
Medium	Medium Sweat Bee	*Halictus ligatus* *Lasioglossum* sp.	Halictidae Halictidae
Small Dark Bee			
Rounded Tip	Sweat Bee	*Lasioglossum* (*Dialictus*) sp. *Lasioglossum* (*Evylaeus*) sp.	Halictidae Halicitidae
Shield (Pointed) Tip	Small Carpenter Bee	*Ceratina* sp.	Apidae
Yellow Face, Wasp-Like	Masked Bee	*Hylaeus* sp.	Colletidae
Metallic Hairy Belly Bee	Blue Mason Bee Green Mason Bee	*Osmia* sp. *Osmia* sp.	Megachilidae Megachilidae
Striped Hairy Belly Bee			
Small	Leaf-Cutter Bee	*Ashmeadiella* sp.	Megachilidae
Small/Medium	Leaf-Cutter Bee	*Megachile* sp.	Megachilidae
Cuckoo Bee			
Red Abdomen	Cuckoo Bee	*Sphecodes* sp.	Halictidae
Small	Cuckoo Bee	*Triepeolus* sp. *Epeolous* sp.	Apidae Apidae
Large	Cuckoo Bee	*Triepeolus* sp.	Apidae

Appendix C

RESOURCES

Publications

Bee conservation

- Buchmann, S.L. and G.P. Nabhan. 1996. *The Forgotten Pollinators.* Washington: Island Press.
- National Research Council. 2006. *Status of Pollinators in North America.* Washington: National Academies Press. (Available online at http://www.nap.edu/catalog/11761.html.)
- Shepherd, M., S. Buchmann, M. Vaughan, and S.H. Black. 2003. *Pollinator Conservation Handbook.* Portland: The Xerces Society. (Information at http://www.xerces.org/books/.)
- Vaughan, M., M. Shepherd, C. Kremen, and S. Black. 2007. *Farming for Bees.* Portland: The Xerces Society. (Available at http://www.xerces.org/guidelines/.)
- Black, S. H., N. Hodges, M. Vaughan, and M. Shepherd. 2007. *Pollinators in Natural Areas. A Primer on Habitat Management*. Portland: The Xerces Society. (Available at http://www.xerces.org/guidelines/.)
- Vaughan, M., and M. Skinner. 2008. *Using Farm Bill Programs for Pollinator Conservation*. USDA-NRCS Technical Note 78. (Available at http://www.xerces.org/guidelines/.)

Bee biology and identification

- Michener, C.D., R.J. McGinley, and B.N. Danforth. 1994. *The Bee Genera of North and Central America.* Washington: Smithsonian Institution Press.
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- O'Toole, C. and A. Raw. 1999. *Bees of the World.* London: Blandford.
- Stephen, W. P., G. E. Bohart, and P. F. Torchio. 1969. *The Biology and External Morphology of Bees; with a Synopsis of the Genera of Northwestern America*. Corvallis: Agricultural Experiment Station, Oregon State University. (Available at http://ir.library.oregonstate.edu/jspui/handle/1957/2080.)

Courses

- Bee Pollination of Spring Wildflowers (http://ucjeps.berkeley.edu/workshops/2008/#Jun6) This is a great course led by Robbin Thorp (UC Davis) and Gordan Frankie (UC Berkeley) and organized by the Jepson Herbarium.
- American Museum of Natural History Bee Course (http://research.amnh.org/invertzoo/beecourse/) This course, led by bee experts from around the US, delves into the systematics and biology of bees.

More Citizen Science Opportunities

- Pollination Canada (www.seeds.ca/proj/poll/) Citizen science "pollinator observer" kit and handbook
- The Great Sunflower Project (www.greatsunflower.org) Citizen science – ID bees that visit sunflowers
- Texas Bee Watchers (http://beewatchers.com) Citizen Scientists monitoring bees in Texas
- Bug Guide (www.bugguide.net) An online resource devoted to North American insects, spiders and their kin, offering identification, images, and information.

Yolo County Partner Organizations

- Audubon California's Landowner Stewardship Program (www.ca.audubon.org/LSP/)
- Center for Land-Based Learning (www.landbasedlearning.org)
- Hedgerow Farms (www.hedgerowfarms.com)
- Natural Resources Conservation Service (www.nrcs.usda.gov)
- The Xerces Society for Invertebrate Conservation (www.xerces.org)
- Yolo Co. Resource Conservation District (www.yolorcd.org)

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Web site: www.xerces.org

California Pollinator Project

Citizen Scientist Pollinator Monitoring Guide

Pollinators are a key component of our environment that link natural areas with developed sites, suburban parks, and farmland. Although they only go foraging to feed themselves and their offspring, the work of bees, flies, beetles, and butterflies provides the essential ecosystem service of pollination. Bees are generally considered to be the most important group of pollinators in North America.

Despite the importance of these animals to our everyday lives—upwards of one third of our diet is the result of their work!—surprisingly little is known about their foraging habits or nesting needs, or even which species live in this region.

Over a period of two years, the California Pollinator Project developed and field-tested this Citizen Scientist Monitoring Guide as a tool to train citizen scientists on how to observe and identify floral visitors, primarily bees, in California's northern Central Valley. When used in a training workshop that includes practice observations with bee experts, this guide and monitoring protocol provides a framework for people to learn how to identify and document the most common and important groups of native bee species found in Yolo County, California.

Green sweat bee (genus *Agapostemon*). © Rollin Coville.

Front cover: Size doesn't matter in pollination. Many bees are very small, such as this greatly magnified sweat bee in the genus *Dialictus*, but are important pollinators of wildflowers and crops. © Rollin Coville.

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