species of damselflies occur in California. They have a characteristic body shape: a long, slender abdomen and a "hammer head," with large compound eyes widely separated on short stalks on either side of the relatively small face. When perching, most of our species carry their wings flat together, or nearly so, above the abdomen. Exceptions to this rule are members of the spreadwing family (Lestidae), which perch with wings held out to the sides, somewhat like anisopterans. The wings of all but two of our species (in the broad-winged damsel family [Calopterygidae]) are distinctly stalked (petiolate) at their bases, and the fore and hind wings are of similar size and shape.

Anisopterans are what most people consider typical dragonflies. Sixty-eight species are known in the state. They are more robust than damselflies and perch with their wings spread. The hind wings are broader at their bases than are the fore wings, prominently so in some species. The large compound eyes are closer to each other than they are on damselflies and even come in contact atop the head in many species. The face is relatively large and flattened.

## Adult Dragonfly Anatomy

Odonates have the basic insect body plan, which consists of a hard exoskeleton fashioned into a head, a thorax, an abdomen, six legs, and four wings. Within this structure, certain details of anatomy, some unique to the group, must be learned in order to readily distinguish among similar species and to properly appreciate observed behavior. I have tried to simplify the descriptions and limit unfamiliar terms as much as possible. See the glossary, figs. 1 and 2, and the following descriptions for help.

### Head

The head is relatively large and dominated by two large compound eyes that are oriented dorsolaterally (upward and to the sides). Each compound eye is composed of thousands of individual lenses, or facets. The color of these eyes in life may be quite striking and is typically darker above than below, often with a sharp break between the two regions. Black spots or lines on the eyes, some-

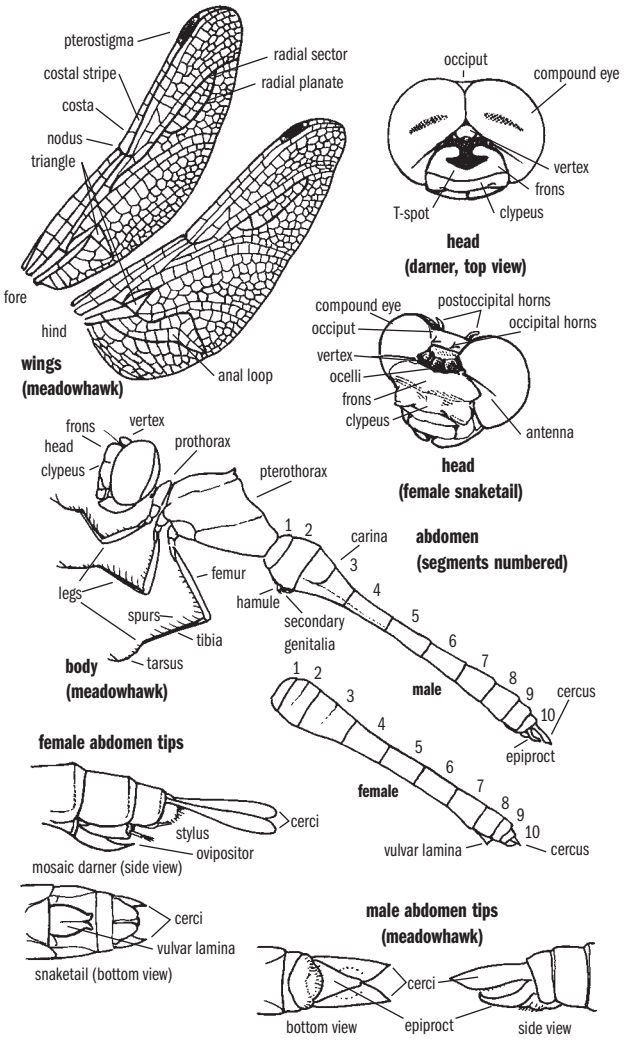


Figure 1. Dragonfly anatomy.

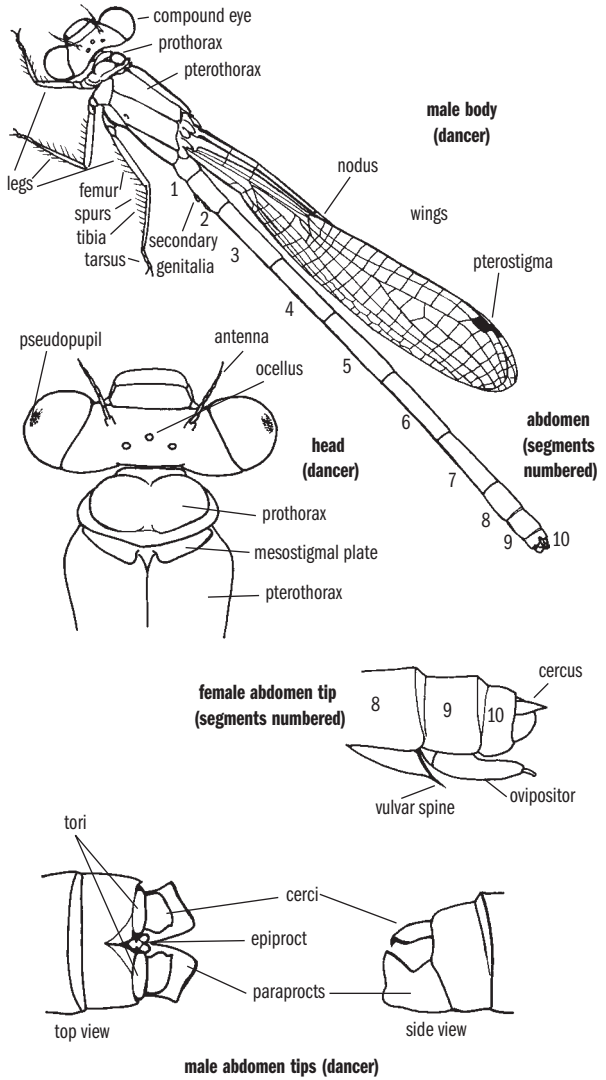


Figure 2. Damselfly anatomy.

times referred to as pseudopupils, are areas of enlarged facets pointed in a particular direction, which is the direction of most acute vision. The front of the face has chewing mouthparts below and is bordered above by a central plate called the clypeus. This plate is separated from the forehead region, a frontal lobe called the frons, by a horizontal groove (suture line). In some dragonfly species, the frons has a distinctive color pattern that resembles a bull's-eye or a capital T (referred to as a T-spot). Behind the frons and between the front of the compound eyes is the vertex, a plate bearing three simple eyes (ocelli). The relatively inconspicuous antennae arise from near the front of the vertex close to the compound eyes. A central plate at the upper rear margin of the head between the eyes is called the occiput. On dragonflies that have compound eyes in broad contact atop the head, the occiput is reduced to a small, triangular region. In some species, particularly some members of the clubtail family (Gomphidae), horns on the top (occipital horns) and the rear margin (postoccipital horns) of the occiput are useful identification features in the hand.

## Thorax

The thorax can conveniently be divided into the prothorax, a small segment attached to the head and bearing the front pair of legs, and the pterothorax, the large, sturdy midsection that houses the flight muscles and bears the wings and remaining two pairs of legs. The pterothorax—often simply referred to as the thorax in this book—is strongly slanted (upper surface backward, under surface forward) so as to project the wings backward and the legs forward. This slant means that what is structurally the front of the pterothorax appears to be on top of the structure. Damselflies have a pair of mesostigmal plates at the leading edge of the front of the thorax just behind the prothorax. On females, these small plates and the prothorax are structures that interact with the male's caudal appendages in tandem linkage, so they often feature important species-specific characteristics useful for in-hand identification. Some odonate species have a distinctive tubercle, or small bump, on the underside of the pterothorax.

## Legs

The legs of odonates consist of the typical, jointed arthropod segments, most notably the femur, tibia, and tarsus. Each tarsus con-

sists of three segments and is tipped with two claws. Spiny spurs line the margins of the femur and tibia. Because of their forward positioning, the legs are of little use for walking; instead, they are used for perching, scooping up and handling prey, and (in the case of the front legs) for grooming the eyes and face.

## Wings

The large, many-veined wings of dragonflies bear many distinctive features. The complex terminology developed for wing venation is, however, beyond the scope of this guide. Key features you should become familiar with, illustrated in fig. 1, are the anal loop, the triangle, the costa and costal stripe, the nodus, the radial planate and radial sector, and the pterostigma. The pterostigma, a thickened, often distinctively colored wing cell along the leading edge of the wing near the tip, apparently serves an aerodynamic function and, in some species, is also an element in visual displays or signaling.

## Abdomen

The abdomen is divided into 10 segments, numbered from 1 at the base to 10 at the tip. The major features of the abdomen useful for identification are the sexual appendages, extending from the terminal segments, and the secondary genitalia of males. The latter are located under abdominal segment 2. Of the many intricate structures that make up the secondary genitalia, the most useful to learn for field identification are the hamules, which are hooklike structures on most dragonflies; they are visible with a hand lens and are often species specific in shape.

The terminal appendages of males, which are used to grasp females by the rear of the head (in typical dragonflies) or the thorax (in damselflies) during mating, are often important features for distinguishing look-alike species. It is therefore worthwhile to learn the names and positions of these structures.

The cerci (singular, cercus) are the pair of upper (superior or dorsal) appendages. When the male curls his abdomen down and forward to grasp the female, the cerci curl under the upper rim of the head (in typical dragonflies) or contact the mesostigmal plates (in damselflies). Male cerci are often relatively large appendages with hooks or spines for grasping. The cerci of females are typically simple, cone-shaped or leaflike structures and only occasionally of use in field identification.

The lower (inferior or ventral) grasping appendages of male damselflies and typical dragonflies are different in nature. Male damselflies have a pair of structures, the paraprocts, that grasp the prothorax during tandem linkage. In some species, these are relatively large and strongly hooked. In nearly all other odonates, the paraprocts are relatively inconspicuous, small, rounded structures. The inferior grasping appendage of typical male dragonflies is a single epiproct (strongly forked in some species) that grasps the top of the head or eyes of females. This structure typically is not a conspicuous feature on female dragonflies or most damselflies. However, on male dancers *(Argia),* the shape and size of the epiproct—which appears as a small lobe projecting rearward from the upper middle rim of segment 10—relative to the shape of the projecting pads (called tori [singular, torus]) on either side of it are of use in identifying some species.

The females of all damselflies and some dragonflies (darner and petaltail families [Aeshnidae and Petaluridae]) have a fully formed ovipositor, which is a complicated structure containing paired valves and cutting blades, on the underside of abdominal segments 8 and 9. The ovipositor is used to insert eggs into plant tissue, mud, or other substrate. Some species have a stylus, which is a thin, needlelike projection, at the end of each of the two valves of the ovipositor. Species without a true ovipositor (most of the typical dragonflies in our area) have a more or less well developed vulvar lamina, a plate that extends rearward from segment 8 to cover part of the undersurface of segment 9. This plate, which is often distinctly bilobed, may be used to carry egg masses or otherwise aid in the dispersal of eggs. In the spiketail family (Cordulegastridae), the vulvar lamina is highly modified to form a spikelike structure that inserts eggs, much as a true ovipositor might, into aquatic substrates. Some species of damselflies have a vulvar spine on the rear lower margin of segment 8 that projects over the genital opening at the base of segment 9.

You will occasionally find odonates, especially damselflies, with tiny red "beads" attached, often in small clusters, to the undersurface of the thorax or abdomen. These are not part of the odonate but rather are larvae of parasitic water mites, which hitch a ride on odonate larvae and then make the transfer to the adult form at the time of emergence. The mite larvae attach themselves to the hardening body, sucking fluids from their host. When the adult odonate later comes into contact with water—

for example, during oviposition—the mites detach and return to the water to complete their life cycle.

There are few other insects that might be mistaken for odonates. Perhaps most likely to cause confusion are adults of the antlion family (Myrmeleontidae, order Neuroptera), which resemble adult damselflies but have noticeably longer, club-tipped antennae.

## Dragonfly Behavior

Adult dragonflies use vision as their primary means of assessing their environment. In this way, they are like us, and their behavior, as compared to that of many other, more secretive insects, is relatively easy to understand if we simply watch what they do. Many specific behaviors are characteristic of particular species or groups of species, so in making an identification, observing behavior is often as important as noting appearance.

Dragonfly behavior has evolved in response to a few simple needs:

The need to eat
The need to avoid being eaten
The need to reproduce
The need to regulate body temperature (thermoregulation)
The need to disperse

Some of the distinctive behaviors odonates have evolved to meet these needs are discussed in the following sections.

### Feeding Behavior

Dragonflies are voracious predators; they eat just about any animal they can catch and chew, including other dragonflies. Most prey of adult dragonflies are flying insects, taken on the wing. The two general types of aerial feeding used by dragonflies are hawking (the constant pursuit of flying insects) and sallying (darting out from a perch to capture prey and then return to the perch). Hawking dragonflies remind bird-watchers of swifts or swallows and often feed in swarms as do those bird species, whereas salliers are reminiscent of flycatchers. Some species are hover-gleaners,