

UNIVERSITY OF CALIFORNIA, SANTA CRUZ

Syrphidae: A Guide to Natural History and Identification of Common Genera in Santa Cruz County

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ABSTRACT: The Syrphidae (hoverflies) are one of the most biologically diverse taxa in the order Diptera. Hoverflies offer ecosystem services such as pollination, aphid biocontrol, and breaking down decaying organic matter, but the significance for their conservation goes beyond such services. The purpose of this project was to create a resource that helps local naturalists and the wider community develop an interest and awareness of common hoverflies in the Santa Cruz area. I hope this peaks enough curiosity for people to go outside and explore syrphids in their larval and adult homes and subsequently advocate for their conservation. Although a few guides on hoverflies of North America exist, there are none that explicitly cover hoverflies found in California. I used the Randall Morgan Insect Collection to analyze Syrphidae data and determine common genera, host plants, and monthly distributions from 1991-1999. In this guide, I provide a thorough natural and life history of hoverflies, an identification guide to 15 genera, and additional information on plant hosts and times of year when they may be found.

KEYWORDS: Hoverflies, Syrphidae, Natural History, Identification, Yearly Distribution, California, Randall Morgan

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The Syrphidae (hoverflies) are one of the most biologically diverse taxa in the order Diptera, plus they can be found in almost every terrestrial habitat in addition to many aquatic habitats (Dziok, 2006). They are popular and widely known because of their mimicry and resemblance to hymenopteran species like honeybees. While out in the field, the best way to tell them apart is by using the number of wings; bees have two pairs or four wings while hoverflies only have one pair or 2 wings. Under a microscope, however, a distinctive feature that differentiates Syrphidae from bees and other flies is a spurious vein. The Syrphidae family consists of 3 subfamilies, 14 tribes, 200 genera, and around 6,000 described species (Miranda et al., 2013).

In this guide to Syrphidae genera, I first introduce the natural history and life history of hoverflies where I discuss topics of feeding behaviors in larvae and adults, floral selectivity among different genera, life cycle and reproduction, overwintering strategies, mimicry, and parasitoid host relations. I use the terms hoverfly, flowerfly, and syrphid interchangeably throughout the paper as a common term that represents all Syrphidae flies. I also use the Randy Morgan Insect Collection (RMIC) Syrphidae data from 1991-1999 and relate it to the information found in the scientific studies I discuss. In the second portion of this guide, I identify some of the common genera in Santa Cruz County, and point out which characteristics can distinguish between similar species. In the 2nd portion of the guide, I also use the RMIC data to relate to the population in Santa Cruz and share information about the most abundant times of the year, highly visited plants, and preferred habitats for different genera, all in the context of Santa Cruz County.

Dietary Behaviors in larvae

Hoverfly feeding behaviors vary for each genus, and their larvae have even more diverse feeding patterns. *Eristalis* and species in the genera *Syrphinae* and *Microdon* illustrate the diverse feeding patterns of the syrphid family since their larval forms occupy more diverse niches than their adult forms (Gilbert and Owen, 1990; Klecka, Hadrava, Biella, & Akter, 2018; Perez-Lachaud, Jarvis, Reemer, and Lachaud, 2014). The feeding behaviors for most species in Syrphidae, however, tend toward specialization, and many researchers believe this pattern is a result of competition (Gilbert, 1981; Klecka et al., 2018; Perez-Lachaud et al., 2014). For example, the Syrphini tribe and most of the Syrphinae subfamily have predatory larvae that feed specifically on aphids, but because these larvae are voracious predators, they can easily obliterate aphid colonies. As a result of these hungry and fast acting Syrphinae larvae, competition is a large influence on food source availability for other species.

For larvae to survive, the female hoverfly must find a suitable food source to lay her eggs near. Adult female hoverflies in Syrphinae, for example, must find an aphid-infested plant to provision her young. She utilizes the sweet aroma of the honeydew that aphids secrete and then lays her eggs on the underside of the leaf. Once the gelatinous larvae emerge, it sways its eyeless head right and left and uses its sensory structures to detect aphids. It is incredible that individual hoverfly larvae are capable of ingesting at least 200 aphids in the course of its development (Sutherland, Sullivan, & Poppy, 1999). There is much pressure on this food source, therefore, such competition for aphid resources can lead a species to tend toward a different food source.

The only phytophagous species of the Syrphinae subfamily illustrates a good example of how competition drives species to become specialists. Researchers believe this species, *Allograpta centropogonis*, has evolved to feed on plant tissue because of the intense pressure on aphid food sources (Nishida, Rotheray, & Thompson, 2002). As a result of this evolution, *A. centropogonis* displays unique morphological features on its face, which are greatly projected anteriorly. In addition to less competition, it is possible that this evolutionary shift happened so larvae could utilize plant toxicity as a defense from predators (Nishida et al., 2002). Plant tunneling feeding behavior also provides maximum consumption of soft, nutritious plant tissue as well as protection from strong winds and other environmental factors. Even with this protection, Nishida et al. (2002) report there are other natural enemies, such as unknown syrphid species, that prey on the eggs of *A. centropogonis*. Nonetheless, the evolutionary step of feeding on plant tissue as opposed to aphids demonstrates the effects competition may have on feeding patterns.

Ants are another resource that hoverfly larvae utilize. Each subfamily (Eristalinae, Syrphinae, Microdontinae) contains at least one species that is a myrmecophile, meaning they live in close association with ants and their nests (Cheng & Thompson, 2008; Perez-Lachaud et al., 2014). In the subfamily Microdontinae, the adults of *Hypselosyrphus trigonus* have evolved to parasitize ants, and thus larvae have a precarious feeding pattern. This mode of feeding is correlated with their suctorial mouthparts which cannot tear or pierce ant cocoons (Speight, 1987; Gilbert & Jervis, 1998). The female adults of *H. trigonus* are hypothesized to specialize only on a subset of ant hosts that have strongly developed liquid food exchange by regurgitation (Perez et al., 2014). Feeding by regurgitation allows hoverfly larvae to conserve energy and take ant resources instead. Myrmecophilous larvae that do **not** belong in the Microdontinae subfamily like *Chrysotoxum meigen* (Syrphinae), *Pipizella rondani* (Eristalinae), and *Xanthogramma schiner* (Syrphinae) prey on ant-attended root aphids within the host nest

(Perez et al., 2014). Instead of directly feeding on ants, they utilize ant nests as resources to get to the aphids they seek to feed on.

In their adult forms, hoverflies focus more on floral selectivity since they feed on nectar and pollen. Several factors may contribute to this selectivity including morphological characteristics (Gilbert et al., 1985), phylogenetic relatedness, floral color, and plant traits (Klecka et al., 2018; Haslett, 1989). In the *Microdon* genus, however, adults do not portray similar behavior to other Syrphidae adults, instead of typical flower-visiting behavior, some species remain near their larval host colonies.

Floral Selectivity in adults

For most hoverfly species there are specific factors that can determine whether they specialize on collecting pollen, foraging for nectar, or both. The nutritive value of pollen comes in the form of protein and amino acids. For several genera like *Metasyrphus*, pollen plays an important role in reproduction. Pollen specialists are usually smaller in size and devote more resources to reproduction (Gilbert, 1981). These specialists rely on cropping large amounts of pollen to obtain energy and resources. Larger syrphid species do not devote as many resources to reproduction as smaller species do. Instead, they rely mainly on nectar to gain their energy and to a smaller scale rely on pollen for particular nutrients (Van Rijn & Wackers, 2016).

Although Syrphidae flies are generally opportunistic feeders, morphological traits of hoverflies such as body and proboscis size are thought to be one of the biggest influencers of flower visitation (Gilbert et al., 1985). The relative size of the labella is also highly correlated with the patterns of pollen feeding. The larger the labella, the more likely it is for that particular species to depend on pollen (Gilbert, 1981). Another characteristic related to pollen collecting is the specialized body hair which is denser on some species than others. Rather than feeding directly from a flower, the pollen adheres to their hairs allowing them to ingest it mid-flight or as they clean themselves (Gilbert, 1981). This adaptation improves efficiency by reducing the time it takes to crop pollen from the anthers of a flower. Larger and hairier flies like the cosmopolitan fly *E. tenax* and *Scaeva pyrastar* collect and ingest pollen almost exclusively from nectar-bearing flowers (Holloway, 1976). Comparatively, smaller and less hairy species like those in *Melanostoma* and *Platycheirus* also demonstrate selectivity in their preference of wind-pollinated plants like *Baccharis pilularis* and their tendency toward visiting one to two plant families (Holloway, 1976).

Floral morphology also plays a role in what species of hoverflies they attract. For example, inflorescence height and corolla depth of a flower affect the species that can forage there. The genus *Rhingia*, for instance, is a great example of the adaptive pressure to specialize feeding patterns toward a subset of flowers. In comparison to other genera, *Rhingia* species have labella, the pair of lobes at the tip of the proboscis (Fig. 1), which is narrow and pointed as opposed to broad and flat (Gilbert, 1981). This characteristic acts as a sponge at absorbing liquid. Subsequently, nectar foraging efficiency increases in flowers



Figure 1. *Rhingia* sp. uses narrow and pointed labella to forage nectar effectively. Science Photo Library: Wim Van Egmond.

with deeper corolla tubes like fuchsia flower or sticky monkey flower. This is contrasted to most hoverflies, which prefer to visit open, bowl-shaped flowers (Gilbert, 1981).

Flower color and the resource availability of a particular environment also affects floral selectivity. Hoverflies can experience competition for floral resources since most species prefer to forage among yellow, white, open flowers with radial symmetry and shallow nectarines (Gilbert, 1980; Sajjad & Saeed, 2010). These features are found on umbel flowers like those in the family Apiaceae. A great example of feeding specialization to avoid competition is seen in the marmalade fly, *Episyrphus balteatus*, which can overcome its instinct toward yellow flowers by using floral scent instead of visual cues to visit non-yellow flowers (Primante, 2010). Floral color selectivity can be an important factor to help reduce resource overlap. For example, when feeding during herbaceous blooms, which generally provide a breadth of floral resources, *Eristalis tenax* and *Eristalis pertinax* demonstrate selectivity by their color preferences (Haslett, 1989). *E. tenax* preferred blue and **high** reflected ultraviolet yellow flowers while *E. pertinax* preferred white and **low** reflected ultraviolet yellow flowers (Haslett, 1989). In other words, these species gear toward selectivity depending on reflectance spectra of a flower. It is important to note, however, that these colors represent foraging preferences of specific hoverfly species and do not represent a difference in their visual systems (Haslett, 1989).

Reproduction

There are two main strategies that male hoverflies use to find mates. While some animals lump all their needs like food, rest and mating into one habitat, hoverflies like *Eristalis tenax* prefer to separate its off-duty tasks like basking, grooming and feeding from its on-duty task of patrolling for a mate (Maier & Waldbauer, 1979). Species like *Mallota posticata* and *Spilomyia decora* wait near oviposition sites like rot cavities to await the arrival of a female looking to oviposit (Maier & Waldbauer, 1979). Other species like *Mallota bautias* and *Spilomyia hamifera* use the patrolling method where they select a particular plant or bush to patrol for mates (Maier & Waldbauer, 1979). This is considered their mating territory, which is different from their resting, shelter, and feeding locations and is protected much more aggressively. Both strategies rely on seeking females only near floral resources and rot cavities.

On warm days in the spring and summer generations, syrphids are active for up to 7 hours a day and half of this time is dedicated to off-duty tasks. While patrolling, male hoverflies are alert, cock their head, shift positions often, and most importantly remain in a crouched position ready to launch at intruders (Wellington & Fitzpatrick, 1981). When the intruder is a female hoverfly, the male clasps her, they hover in tandem, then settle to mate on nearby foliage. For male intruders, however, hoverflies behave pugnaciously, always eager, and ready to fight. If another syrphid fly or an alien species enters the mating territory, *E. tenax* will belligerently shoulder into the offender and chase it away for up to 15 m (Wellington & Fitzpatrick, 1981). The continuous demands of territorial duty ultimately increase hoverfly's aggressiveness towards other unrelated species. *E. tenax* can be so aggressive, they have the potential to reduce pollinating efficiency of honey bees and bumblebees (Wellington & Fitzpatrick, 1981).

Life Cycle

A hoverfly's life span ranges from a few hours, to several weeks, to up to six months and pollen plays an important role in reaching sexual maturity. Males require pollen when they are newly emerged to mature the testes and initiate sperm production (Gilbert, 1981). Females in some species require pollen for egg maturation.

The life cycle of a hoverfly begins unlike social insects which use their energy to forage resources for the nest and their colony. Instead, the adult female only needs to provide for herself while finding first a mate and then a suitable place to lay her eggs (Shepherd, Hoffman-Black, Buchmann, & Vaughan, 2003). Flies lay their eggs within or near a suitable food source. The food source differs depending on the genus but Syrphinae eggs are laid by a large abundance of aphids (Perez-Lachaud et al., 2014).

Egg and larval development can differ depending on the genus. Most species of hoverfly eggs are white, gray, oblong-shaped, covered in a sticky substance, and can be laid neatly on the underside side of a leaf (Milne and Milne 1980). After 3-4 days the eggs hatch and enter larval development. During the larval stage, some species like those in Syrphinae display the maggot shape most people are familiar with. They molt three times and increase in size through every molt. Larvae in the third instar vary in color but can be distinguished from other insect larvae by their tapered body, pointed head, opaque skin with a glimpse of internal markings, and legless and eyeless bodies (Rotheray, 1993). After larvae consume enough food to reach full development they are ready for the pupation stage. In this stage, larvae form a green or dark brown pupa, remain on a plant, or drop to the surface of the soil, and enter a sessile stage where larval structures are broken down, and adult structures are formed (Pfiester & Kaufman, 2009). Some species in Eristalinae and Syrphinae begin to emerge in April and May, around the time temperature and aphid populations increase (Gilbert, 1980). Generally, the hoverfly life cycle is completed in 16-28 days, and for some genera, 3-7 overlapping generations occur throughout the course of a year.

The life cycle of some species in Microdontinae and Eristalinae subfamilies differs greatly from other genera. Most species in Microdontinae live near ant nests, use ants as a food source, or rely on them to obtain food. Unlike larvae in other genera, *Microdon* does not have apparent body segmentation and display a peculiar mollusk shape. Remarkably, female *H. trigonus* lay their eggs directly in the prepupae of ant hosts (Perez-Lachaud et al., 2014). This allows larvae to conserve its energy and feed on ant brood and its resources instead. Additionally, one of the most common hoverfly species, *E. tenax*, is known as the rat-tailed maggot because of its precarious larval form. This aquatic larva thrives in nutrient-rich and polluted waters, manure, and even in animal carcasses (Pfiester & Kaufman, 2009). Its cylindrical body is segmented and has a specialized organ called the siphon which is located on its posterior end (Metcalf, 1913). The siphon is a respiratory appendage that looks like a long tail, resembling that of a rat's, hence the name rat-tailed maggot. In the pupation stage, the pupa is shorter and thicker and also has two pairs of horns or cornua placed on the thorax (Metcalf, 1913). This unique morphology allows it to feed on decaying organic matter. The difference in feeding patterns for these species from different subfamilies could possibly be attributed to their varied life cycles.

Overwintering and Estivation

Hoverfly life patterns are diverse even when it comes to surviving extreme weather like drought and freezing temperatures. The mechanisms used to survive extremities are diapause,

migration, and some species use a combination of both. Just like humans and other animals, migration for hoverflies provides access to favorable living, feeding, and breeding conditions. For highly mobile species like *Metasyrphus corollae* and *E. balteatus* aphid abundance triggers their migration illustrating the power that competition for a food source can have. These species can travel as much as 111 km in a day compared to non-migrants who only reach 0.4 km (Dziock, 2006). Many migratory species, however, exhibit a partial migration pattern where some populations of the same species are non-migratory and overwinter locally instead of migrating (Hondelmann, 2007). This pattern is a result of slow larval development, which forces them to stay local. During the colder months when aphid populations are low, overwintering hoverflies look for protection from strong winds within perennial habitats (Chaplin-Kramer, Valpine, Mills, & Kremen, 2013). During drier and hot summer months, some hoverflies inhabit areas with little water fluctuation and rely on constant humidity. Often, these species can only survive by relocating to a closer wetter habitat. Although it allows them to survive, this practice can confine migrant species to just one location during the non-migration season (Dziock, 2006). This can likely affect its chances of reproducing.

Hoverflies that do not have the capacity to migrate can survive extremely cold temperatures by entering a state of diapause or dormancy where development ceases. *Microdon mymiae*, a species in the Microdontinae subfamily utilize ant nests as an overwintering habitat during its third larval instar and as adults. Species in other subfamilies begin overwintering once they store enough fat from feeding, then pupate by dropping to the ground, and bear through the cold winter nestled in the leaf litter (Hart & Bale, 1997). Adult hoverflies overwintering in cold climates halt gonad development and instead accumulate energy reserves through fat storage in the body (Hondelmann, 2007). Adult males of *E. balteatus*, however, are unable to increase in size and thus do not overwinter in temperate regions.

While in a state of diapause, hoverflies are still susceptible to low temperatures and the “freeze-thaw” process where temperatures fluctuate between freezing and warm. These extremities can be too harsh for some hoverflies to handle. Cold-hardy species like *Syrphus ribesii* can survive this process by utilizing a mixed strategy of freeze tolerance and freeze avoidance by supercooling which allows them to prevent freezing even when temperatures are extremely low (Hart & Bale, 1997). Species without freeze avoidance by supercooling are unable to handle the stress of several freezing and thawing events and are less likely to survive (Hart & Bale 1997). This characteristic may also play a role in which species could better adapt to survive climate change.

Mimicry

One of the biggest reasons why hoverflies are known is because of their Batesian mimicry and resemblance to bees and wasps. The banded yellow and black coloration that some species display intend to confuse birds and other predators and deceive them into thinking they're noxious insects. This mimicry is not just physiological, but it is behavioral as well. Hoverflies display behaviors like mock stinging, wing wagging and leg waving in an effort to closer resemble the unpalatable wasps and bees.

In addition to confusing predators, the black and yellow markings allow hoverflies improved access to foraging. Wasps are territorial and often act aggressively toward different species so they are much less likely to attack hoverflies that look like their kind (Rashed & Sherratt, 2006). For other species however, mimicry is more than just protection while they are foraging. Flies in the genus *Volucella*, for example, are large fuzzy flies that resemble bumble bees and use their mimicry to enter the nests of bumblebees to lay their eggs. Once the hoverfly eggs have hatched, the larvae feeds on dead bees and other detritus in the nests (Shepherd et al., 2003).

Generally, most species exhibit mimicry as adults, but three Microdontinae species exhibit ant mimicry in their larval form. Larvae are equipped with a special chemical and physical attributes that allow them to become integrated into the ant colony to avoid being persecuted by other ants or simply being chemically indifferent (Witek, Canterino, Balleto, & Bonelli, 2012). The most interesting part is that the first and second instar of *Microdon albicomatus*, *M. cothurnatus*, and *M. piperi* larvae resemble the ant cocoons that they prey on (Garnett, Akre, & Sehlke, 1985) Worker ants then transport syrphid larva around the ant nest without knowing it is not the ant brood.

Parasitoid-Host Relations

Parasitoids are unlike parasites because they ultimately kill the host they are deriving nutrients from. A wide range of parasitic Hymenoptera attack aphid Syrphidae, the most common being Diplazontinae (Ichneumonidae), Figitidae (Cynipoidea). Parasitoids use several chemical cues to locate their host and find syrphids among aphid colonies (Rotheray, 1981). Parasitism occurs frequently on a small number of syrphid species such as: *Syrphus ribesii*, *Episyrphus balteatus*, *Platycheirus scutatus*, *Metasyrphus luniger*, *Scaeva pyrastris*, *Sphaerophoria* sp. (Rotheray, 1981). This selectivity of a particular species indicates most parasitoids have of host preference.

Although syrphids are used as hosts and are often parasitized, there is one known syrphid in the Microdonitinae subfamily, *Hypselosaurus trigonus*, that parasitizes ants. The discovery of this species was the first recording of a primary parasitoid attacking a ponerine arboreal ant, *Pachycondyla villosa* (Perez-Lachaud et al., 2014). Since *Microdon* larvae are scavengers or predators in ant nests this evolutionary step was unusual, but not unexpected for researchers.

Flies use several environmental cues to locate their hosts and habitat. For example, some species of the family Phoridae, a type of fly that parasitizes ants, evolved the means to exploit communications systems and sense alarm pheromones when there is danger or if the ant colony is vulnerable (Perez-Lachaud et al., 2014). So, quite literally these flies can smell fear and can sneak right in to ant nests without being noticed. In the Syrphidae family, female *Hypselosaurus trigonus* lay their eggs directly on the prepupae of their ant hosts. However, scientists have not figured out how the adult female enters the nest, nor how she may deal with aggression from ant hosts (Perez-Lachaud et al., 2014). Since *H. trigonus* cannot pierce and oviposit her eggs, the female possibly lays the eggs as the ant larva finishes spinning its cocoon.

Randall Morgan Insect Collection- Syrphidae Data

Randall Morgan, was a passionate naturalist who collected plants and insects throughout Santa Cruz County and was a huge advocate for biodiversity conservation. His collection of ~70,000 insect specimen consists of ~3,500 Syrphidae occurrences throughout the county from 1991-1999. Of the 200 known syrphid

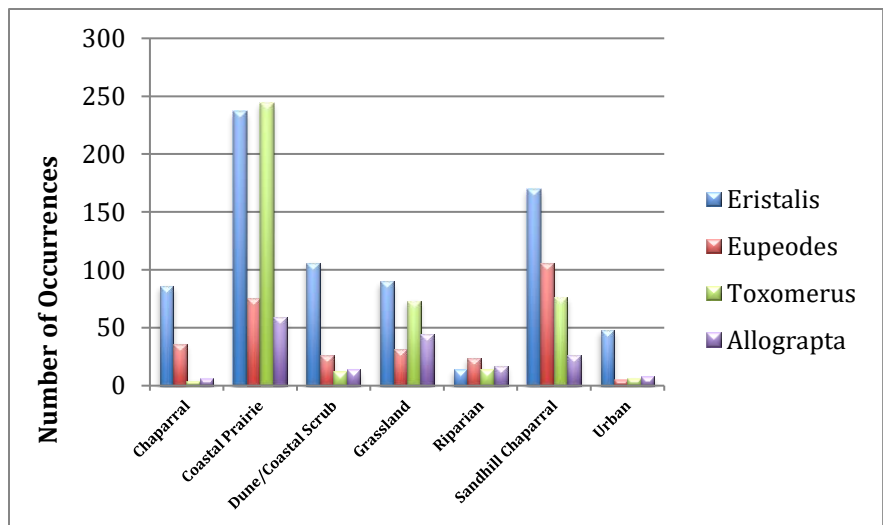


Figure 2. Differences among four most abundant Syrphidae genera by habitat type in Santa Cruz County from 1991-1999.

genera, Randy's collection represents ~40 of those genera. The most abundant genera found in Santa Cruz County include *Allograpta*, *Eristalis*, *Eupeodes*, *Paragus*, *Platycheirus*, *Sphaerophoria*, *Syritta*, *Syrphus*, and *Toxomerus*. Of which, subfamily Syrphinae had the most

occurrences, followed by *Eristalinae*, then Microdontinae with only 3 occurrences throughout the sampling period. Morgan's data is a crucial piece to understanding plant-pollinator networks and interactions in Santa Cruz and how the distribution and abundance of species have changed over time.

In Morgan's collection, Syrphidae occurrences show a preference towards a subset of plants from those found in Santa Cruz County. The drone fly, *Eristalis tenax*, is the most abundant species in the

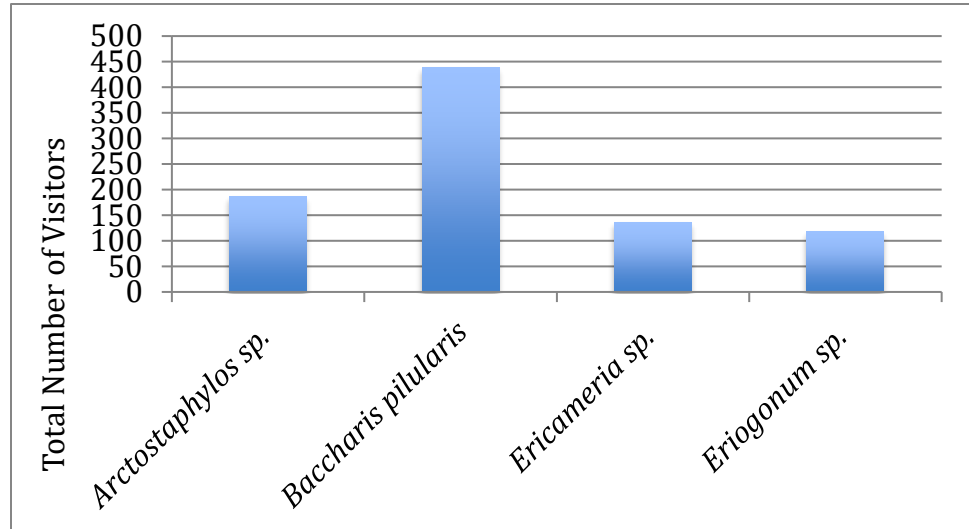


Figure 3. Four plant species most commonly visited by Syrphidae species from 1991-1999 in Santa Cruz County.

syrphid collection, and Morgan recorded over 700 occurrences of *Eristalis*. This genus appears to prefer a coastal prairie habitat (Fig. 2) and frequently visits plants like coyote brush and California golden bush. The data show that hoverflies mostly frequented white and yellow flowers from *Baccharis pilularis*, coyote brush (Fig. 3). This correlates with scientific findings that syrphids have a strong preference for white and yellow colored flowers (Sajjad and Saeed, 2010). The second mostly frequented plant genus was *Arctostaphylos* sp. with many occurrences of Manzanita. *Ericameria* sp. occurrences consisted mostly of California golden bush flowers, and the *Eriogonum* sp. were mostly naked buckwheat flowers (Fig. 3).

Additionally, the fact that coyote brush was so widely preferred compared to other plants may suggest syrphids have a specialization or strong preference toward this flower, or it may be that coyote brush is the most abundant and available resource. This plant has easily accessible flowers, is aromatic, and is often highly abundant, which can explain its popularity. Other commonly visited plants included: telegraph weed, flatweed, and California buttercup. These flowers are all yellow, and have radial symmetry, a preferred plant trait of this family (Gilbert, 1981). More frequently visited but less abundant plants include Kellogg's yampah (*Perideridia*) and wild carrot (*Daucus carota*) which both have white umbelliferous flowers, another syrphid preferred trait (Sajjad & Saeed, 2010). Though this data is not representative of

all the genera of Santa Cruz County, it still gives a great idea of patterns occurring within common genera.

In Santa Cruz, from 1991-1999 the most abundant genera, *Toxomerus*, *Eupeodes*, and *Eristalis* were less abundant at the beginning of the year from January through March and in April their abundance increased (Fig. 4).

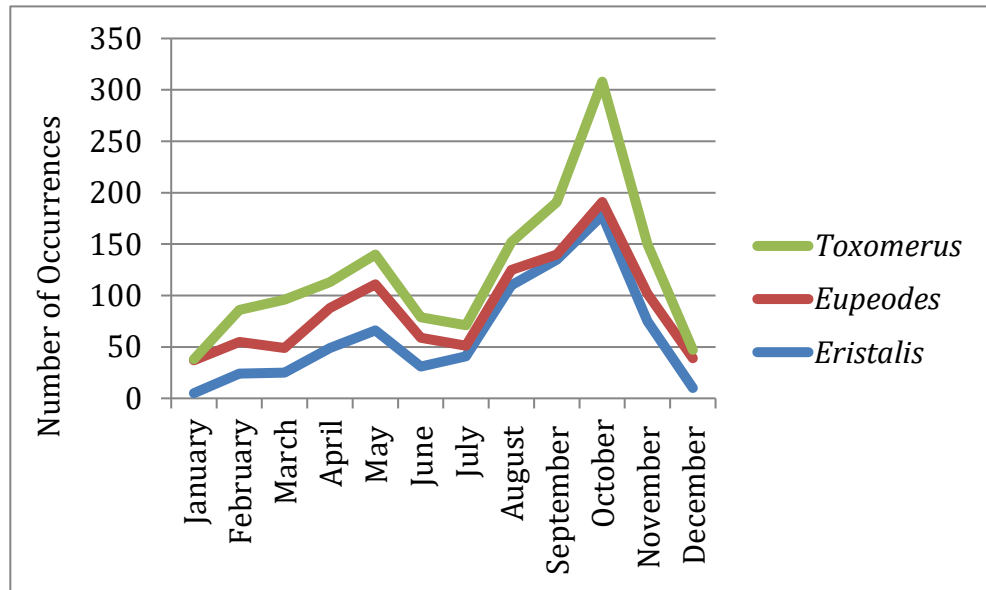


Figure 4. Monthly distribution from 1991-1999 of three most abundant syrphid genera in Santa Cruz County.

The most abundant time of year for these genera was August to November with a peak in October. In Santa Cruz, this timing corresponds with the timing that the mostly visited flower, coyote brush, is in full bloom. When this flower blooms, it is highly abundant and often the only one blooming.

Guide to Syrphidae Genera Found in Santa Cruz County

Tribe: Eristalini

Eristalis

Description and Identification Features

This genus is commonly represented in the Santa Cruz area. The species in *Eristalis* are often referred to as the drone flies because of their resemblance to male honey bees or drones. They are both broad bodied, have similar coloration, big eyes, and a rounded abdomen. *Eristalis tenax* (Fig. 5a) is recognized as the “cosmopolitan fly” because of its wide distribution throughout the world. The males of *E. tenax* are territorial and aggressive when patrolling for a mate. They behave pugnaciously toward other males and different species. Some will even dart into bumblebees and chase them away from their mating territory. This aggressive behavior often discourages other pollinators from foraging in the same area and could have a negative effect on plant fitness.

Eristalis are bulky flies with long, black, brown, and yellow hairs throughout portions of their body. They also display very short hair on the bottom half of the arista. The lack of patterns and markings on the scutum can help differentiate from a similar genus, *Palpada*. A distinguishing feature of this genus is the lack of hair below the posterior spiracle on the metepisternum (Miranda et al., 2013).



Figure 5a. *Eristalis tenax*, a highly abundant, honey bee mimic. From Lloyd Spitalnik 2006.



Figure 5b. *Eristalis arbustorum*, distinguished by white tergal borders. From bugguide.net user iNaturalist/Odophile 2017.

***Eristalis* (continued)**

Local plants where you could find *Eristalis*

Eristalis showed a strong preference for *Baccharis pilularis* or coyote brush. The genus *Eriogonum* was widely noted but naked buckwheat was the flower mostly visited. This plant blooms in the spring, which corresponds with the heightened abundance of *Eristalis* in May. *Ericameria* and the plant CA goldenrod where also highly visited. This plant and coyote brush bloom in the fall which is when *Eristalis* abundance peaked.

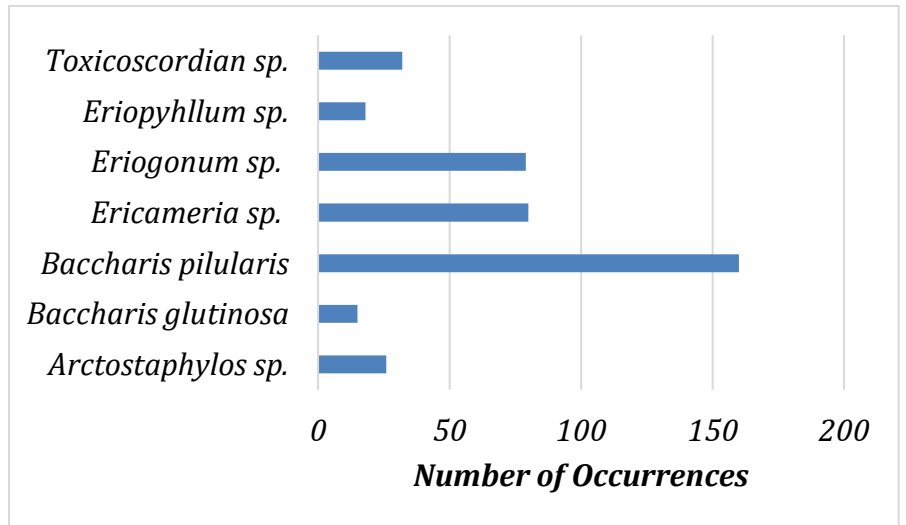


Figure 6. Plant genera and species most visited by *Eristalis* from 1991-1999 in Santa Cruz County.

Merodon

Description and Identification Features

The species *Merodon equestris*, or the “Narcissus Bulb Fly” in the genus *Merodon* is the only species in our region and is considered an introduced pest (Miranda et al., 2013, p. 247). This bumblebee mimic lays her eggs at the base of narcissus plants so when larvae emerge they can feed by tunneling through the plant bulb. This species occurs in different color morphs. Some combinations include: black, yellow, and pale yellow as well as a variation of orange and pale yellow (Fig. 7a).

This genus has similar coloration to other genera like *Volucella* but can be distinguished by its concave face with slight swelling directly below the antennal base (Fig. 7c) (Miranda et al., 2013). Additionally, a recessive M1 vein on the wing (Fig. 7b) and a forward-facing triangular plate on the hind femur, can assure the identification of this species.

Local plants where you could find *Merodon*

Many of the specimen for this genus were not collected from a plant or the plant name was not noted. Flowers this species was recorded on include: two occurrences visiting hairy rock rose, and one occurrence for cut leaf geranium and *Syringa* sp.



Figure 7a. *Merodon equestris*, orange, black, and pale-yellow morph. From bugguide.net user Animal Guy.



Figure 7b. Female *M. equestris* with distinct recessive M1 vein. From University of California Santa Cruz.



Figure 7c. Concave face on *M. equestris*, with slight swelling directly below the antennal base. From Correa 2019.

Sphecomyia

Description and Identification Features

The species in *Sphecomyia* are outstanding wasp and yellow jacket mimics. *S. vittata* displays long black antennae (Fig. 8a) and are aptly nicknamed the “long-horned yellow jacket fly.” *S. brevicornis* (Fig. 8b) can be distinguished by the somewhat elongated antennae, stripe and lack of yellow, pollen-like dust on the scutellum (Hauser et al., 2019).

The species in this genus have nearly cone shaped, downward projected faces (Fig. 8b). This feature can help distinguish it from *Temnostoma* which is a similar genus but lacks a produced face (Miranda et al., 2013, p. 78). The elongated antennae can also help distinguish it from other yellow jacket mimics which have short antennae. *Sphecomyia* has solid black eyes unlike *Spilomyia*, a similar wasp mimic, which has intricate dotted eye markings.

Local plants where you could find *Sphecomyia*

Not many species of this genus are represented in RMIC but, plants where this genus was recorded include: *Arctostaphylos* sp., toyon, and arroyo willow.



Figure 8a. *S. vittata*, distinguished by long black antennae. From Benoit Guenard 2008.



Figure 8b. *S. brevicornis* displaying downward projecting cone-shape face, a distinguishing *Sphecomyia* feature. From Andy Kulikowski 2018.

Spilomyia

Description and Identification features:

The species in this genus are large wasp mimicking flies with yellow and black abdominal patterns. Not only does this genus look like wasps but they also behave like wasps to fool predators into thinking they're noxious and unpalatable. Similar to the way wasps sway their long antennae, *Spilomyia* rests on its four posterior legs, lifts their darkly colored two front legs, and waves them around to make itself look even more like a wasp (Thompson, 1997). They also wag their wings back and forth to mimic the way wasps beat their wings as a warning signal that they're ready to attack.

The eyes on *Spilomyia* species are a distinctive characteristic which usually display vertical, and irregular stripes or blotches (Fig. 9b). Most species in this genus also have a 'v' mark on the thorax (Fig. 9a). Below the antennal base, the species in this genus have a straight rather than concave or greatly projected face (Miranda et al., 2013). A key feature that distinguishes this genus from similar wasp mimics like *Spehcomyia* and *Temnostoma* is the pre-apical spur found on the hind femur, which other genera lack (Fig. 9c) (Miranda et al. 2013).



Figure 9a. Female *S. interrupta* with distinctive "v" mark on thorax. From bugguide.net user iNaturalist/ Odophile 2018.



Figure 9b. Female *S. interrupta* with distinctive eye markings. From bugguide.net user iNaturalist/ Odophile 2018.



Figure 9c. Distinctive preapical spur found on hind femur of *Spilomyia* species. From Correa 2019

***Spilomyia* (continued)**

Local plants where you could find *Spilomyia*

The specimen that were collected on a plant visited *Baccharis pilularis* (coyote brush) and *Perideridia kelloggii* (Kellogg's yampah) which both develop white flowers. The former is wind pollinated and the latter is an umbel shaped flower which are both characteristics preferred by most syrphids (Gilbert, 1980).

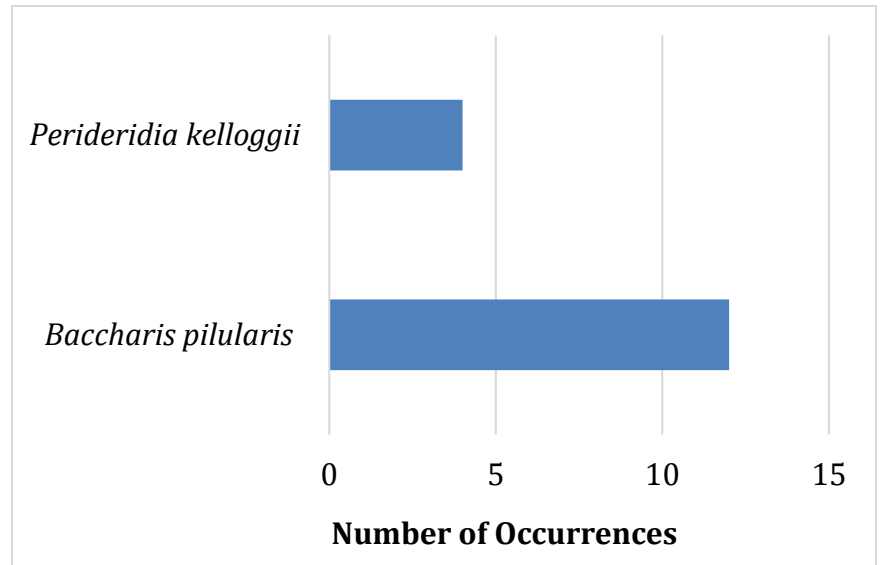


Figure 10. Plant species most visited by *Spilomyia* species from 1991-1999 in Santa Cruz County.

Tribe: Volucellini

Copestylum

Description and Identification Features

This genus includes species of diverse colors and sizes but all with a similar shape. Some species mimic bumble bee colors and others display a beautiful metallic sheen on their abdomen. Adults can be found on flowers, but larvae tend to develop and feed on decaying organic matter like rotting cacti and are sometimes found in water filled bracts of *Heliconia* plants. (Marcos-Garcia & Perez-Banon, 2001).

Some species in this genus resemble *Volucella* but can be distinguished by their plumose arista, which is the bristle covered in small fine hairs located between the fly's eyes (Fig. 11b). Another distinctive characteristic of this genus is a protruding oral margin under the front of the head. *Ornidia*, another genus with metallic colored species may be similar but *Copestylum* has a wholly microtrichose, or very finely haired wing, and a strongly curved M1 vein (Miranda et al., 2013)

Local plants where you could find *Copestylum*

Of the six specimens collected in RMIC, five were found on a flower, and four were collected in October. Two of these occurrences were on coyote brush flowers and one occurrence on *Montanoa sp.*, goldenrod, and strawberry tree. Incidentally, during the recent 2018/19 UCSC Grassland Insect Collection, *Copestylum mexicanum* was collected from a male coyote brush flower in October. This may suggest that 28 years later this plant and time of year might still be preferred.



Figure 11a. *Copestylum mexicanum* displaying metallic sheen on thorax and dark base of wings. From bugguide.net user Dvoribird 2016.



Figure 11b. Close up showing plumose arista and protruding oral margin on *C. mexicanum*. From Correa 2019.

Volucella

Description and Identification Features

The species in this genus are broad bodied robust flies that have an uncanny resemblance to bumble bees. Their great mimicry allows them to enter the nests of bumblebees and lay their eggs. Once the eggs are hatched the larvae feed on dead bees and other decayed matter in the nests (Shepherd et al., 2003).

Their face is anteroventrally produced, or points downward, and long hairs cover the thorax and abdomen (Miranda et al., 2013). A distinguishing feature of this genus is the M1 vein that is strongly curved towards the base of the wing.

Local plants where you could find *Volucella*

The plant this specimen was collected from was *Salvia mellifera*, or black sage. This is a great source of honey and is a popular flower among bumble bees as well.



Figure 12a. Volucella sp. displaying black and yellow colors with long hairs throughout its body. From bugguide.net user Joseph V Higbee 2016.



Figure 12b. Volucella bombylans with downward pointing mouth parts and dark colored wings. From Nevin Cullen 2018.

Tribe: Xylotini

Syritta

Description and Identification Features

There are around seventy species of *Syritta* worldwide and two species are found in North America, *S. pipiens* and *S. flaviventris*. The larvae of this genus live in wet decaying organic matter like manure or compost (Balaban et al., 2018a).

S. pipiens is known as the “thick-legged hoverfly” and can be recognized by the spiny ridges along the front edge of the hind femur (Fig. 13a) (Miranda et al., 2013). A feature present on some individuals of *Syritta* are two small white spots directly behind the head, on the thorax (Balaban et al., 2018a). This feature is more pronounced on some individuals and more faded on others. Interestingly, one sure way to identify *S. flaviventris* is if it lacks a spurious vein, a feature that distinguishes syrphids from other flies (Miranda et al., 2013). *S. flaviventris* also has a tubercle located at the base of the hind femur which *S. pipiens* lacks.

Local plants where you could find *Syritta*

The specimen collected from flowers specialized among three abundant plants. There were 11 visitors for *Persicaria sp.* and coyote brush. While naked buckwheat received 12 visitors.



Figure 13a. *Syritta pipiens* with distinctive spiny ridges on the hind femur. From John Lampkin 2016.



Figure 13b. *S. pipiens* displaying two pronounced white spots behind its head, where the thorax begins. From Peter Chen 2010.

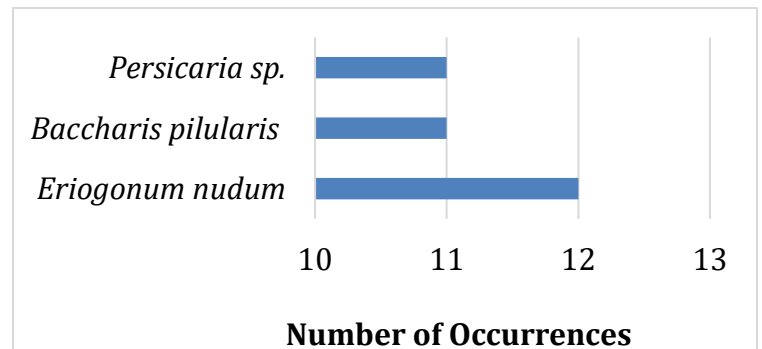


Figure 14. Plant species most visited by *Syritta* species from 1991-1999 in Santa Cruz County.

Subfamily: Syrphinae

Tribe: Syrphini

Allograpta

Description and Identification Features

The name *Allograpta* is derived from the phrase “allo” which in Greek means “another kind of strange” and “grapta” which means “marked.” This refers to the unique patterns and markings *Allograpta* species display on their abdomen (Mengual et al., 2009). Most flies in this genus have a skinny and gradually tapered abdomen (Fig. 15b). They also have well developed slightly dense fringe on the subscutellum. This genus can be identified by a combination of characteristics which include: 1) hairless eyes 2) front part of anepisternum is hairless 3) hairless calypter 4) abdomen without pre-marginal sulcus 5) front to middle of metacoxa is hairless 6) metathoracic pleuron hairless (Mengual et al., 2009).

How to tell *A. obliqua* from *A. exotica*?

It can be hard to tell apart *A. exotica* from *A. obliqua* since they both have similar markings on their abdomen. *A. exotica* has a black stripe down the middle of its face while *A. obliqua* face is completely yellow (Hauser, 2013). The katepisternum, located on the lateral surface of the mesothorax, is black and yellow on *A. obliqua*.



Figure 15a. Female *A. obliqua* with hairless calypter. From Gary McDonald 2010.



Figure 15b. Female *A. exotica* displaying gradually tapered abdomen with distinctive patterns. From Ken Wolgemuth 2019.

***Allograpta* (continued)**

Local plants where you could find *Allograpta*

The most visited flower for this genus was coyote brush (*Baccharis pilularis*). Other common plants visited by this genus include: *Salvia Mellifera* or black sage and *Arctostaphylos sp.*

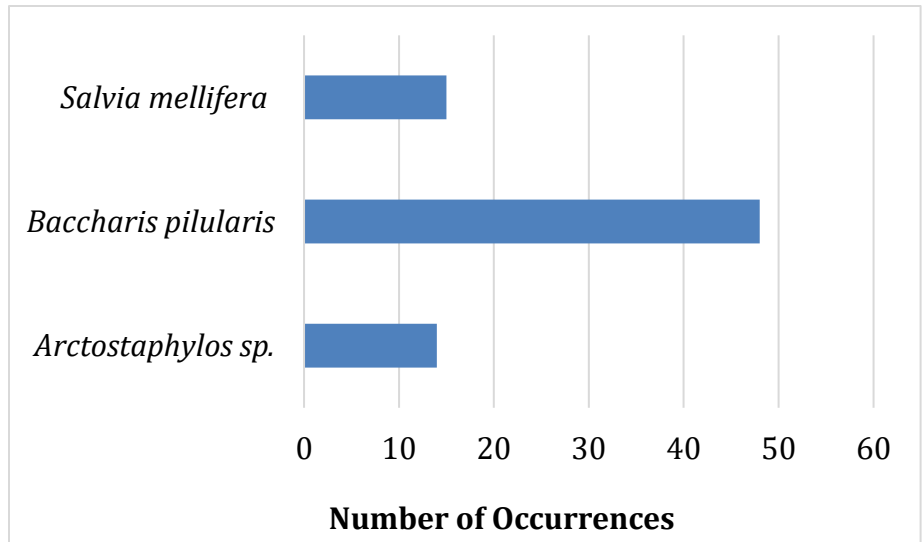


Figure 16. Plant species most visited by *Allograpta* species from 1991-1999 in Santa Cruz County.

Syrphus

Description and Identification Features

Syrphus are medium sized black and yellow flies with yellow bands on the abdomen. Females have an entirely yellow/orange hind femur. These bands vary between individual species and may be completely solid or incomplete. A closer look at the calypter reveals a distinctive feature. The upper surface of the lower calypter is covered in long yellowish white hairs. This feature can help distinguish it from similar genera like *Parasyrphus* which also have complete abdominal

yellow bands but lack the yellow hairs on the calypter (Miranda et al., 2013).

A combination of features distinguishes *S. ribesii* from other species. Generally, this species' face is straight and not produced forward. The length of its face is about as long as its eye height. Their facial tubercle is distinct upward and downward and have a confluent antennal pit in the middle (Mengual et al., 2009). Another distinctive feature of *S. ribesii* are the basal cells on wings that are completely covered with microtrichia (Moisset et al., 2017).



Figure 17a. Basal cells on wings of *S. ribesii* are covered in microtrichia. From Ken Childs 2016.



Figure 17b. Male *S. opinator* with dense, long, and yellowish white hairs on the lower calyptera. From Gary McDonald 2009.

Local plants where you could find *Syrphus*

Similar to other genera, *Syrphus* mostly preferred Coyote brush and *Arctostaphylos* sp.

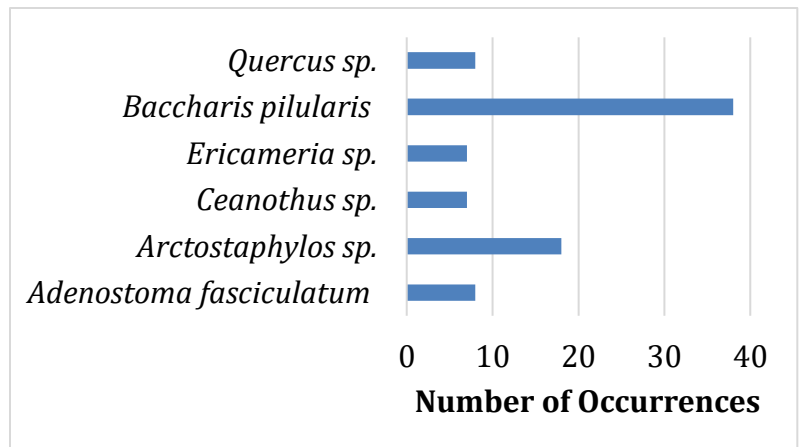


Figure 18. Plant species most visited by *Syrphus* species from 1991-1999 in Santa Cruz County.

Dasysyrphus

Description and Identification Features

North America hosts 36 of the 43 *Dasysyrphus* species that are currently identified. Larvae are arboreal thus adults are often found in or around forests (Locke & Skevington, 2013). The species in this genus are medium sized, about 5.0 - 11.7 mm, compared to the similar sized genus, *Toxomerus* whose body size range from 5-13 mm (Miranda et al., 2013).

One distinctive feature is the lateral grooves located on tergites 3 and 4. The anterior margin of the bands usually do not reach the tergite margin (Miranda et al., 2013). Other distinguishing features include a combination of visibly hairy eyes, densely microtrichose wings, and a bare metasternum (Miranda et al., 2013).



Figure 19. Dasysyrphus sp. displaying lateral grooves that do not completely reach the tergite margin. From Natalie McNear 2009.

Local plants where you could find *Dasysyrphus*

Plants this genus was recorded on include: red osier dogwood, false baby star, and Fremont's star lily. The most common habitats were riparian forest and chaparral. Though these plants are all from different families, their flowers have a couple features in common: white color flowers and radial symmetry. This trend can suggest *Dasysyrphus* may have a preference toward flowers with these characteristics.

Lapposyrphus

Description and Identification Features

There are two species of *Lapposyrphus* in this region, *L. lapponicus*, and *L. aberrantis*. This fly resembles several of the other *Syrphini* tribe members with the black and yellow bands across the abdomen. This genus has broad curved bands across tergite 3 and 4 which sometimes touch and other times are separate.

This genus is similar to *Dasysyrphus* but *Lapposyrphus* displays distinctive bare eyes. Additionally, the R4 + 5 vein appear dipped or bent on *Lapposyrphus* wing can help distinguish from *Eupeodes*. The wings are also densely covered with tiny fine hairs on the top 1/3 of the wing (Miranda et al., 2013, p 92). The species *L. lapponicus* can be differentiated from other species by the yellow line along the margin of tergite 5 (Hauser, 2014).



Figure 20. L. lapponicus displaying bare eyes and distinctive yellow line along tergite 5. From bugguide.net user iNaturalist/ Odophile 2010.

Local plants where you could find *Lapposyrphus*

The most visited plant by this genus was *Arctostaphylos* sp. with three occurrences. Other plants that were recorded with only one visit included: *Althus* sp., *Ericameria* sp., *Pinus* sp., and *Quercus* sp.

Scaeva

Description and Identification Features

This genus is visually similar to other genera like *Eupeodes*. *Scaeva* is generally a bigger size than *Eupeodes* with the former's body size ranging from 11-15.7 mm. *S. pyrastris* is often confused with *E. volucris*. *Scaeva* is differentiated by the dense white hairs on the eyes that resemble a halo (Miranda et al., 2013). *Scaeva* displays sexual dimorphism in their antennae where the female frons are light yellow and narrow while the frons in the male are swollen.

The abdominal markings are similar to other genera in the tribe but one way to tell them apart is the black with narrow, yellow to white, curved bands on tergites three and four (Miranda et al. 2013). These markings are usually uniform in width and unlike genera such as *Lapposyrphus* whose bands sometimes touch, the bands on this genus will never touch. The wings are bare and are actually glossy with very few microtrichia.



Figure 21. Male *S. pyrastris* with distinctive densely haired eyes and separate tergal bands. From Lynn Monroe 2009.

Local plants where you could find Scaeva

The most visited flower for this genus was *Salvia Mellifera* or black sage which is a plant that tends to bloom starting in winter and spring. Other common plants visited by this genus include: *Lupinus sp.*, California yerba santa (*Eriodictyon californicum*), and coyote brush (*Baccharis pilularis*).

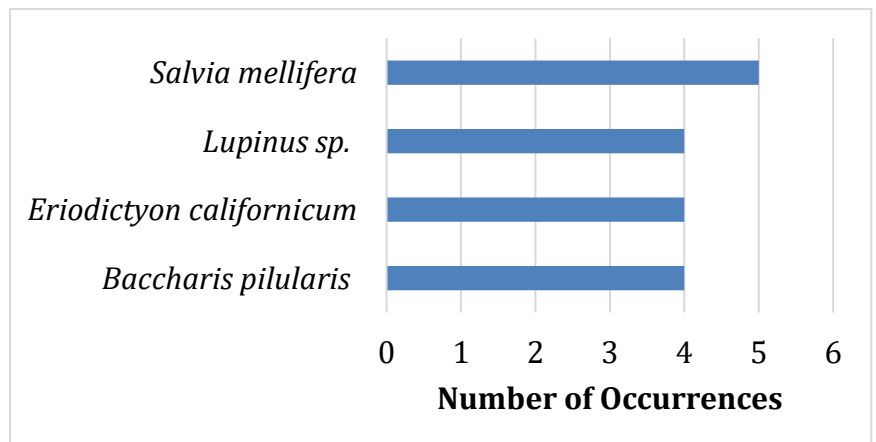


Figure 22. Plant species most visited by *Scaeva* species from 1991-1999 in Santa Cruz County.

Sphaerophoria

Description and Identification Features

This genus is distinctive because of its elongated abdomen and the bold yellow markings along it. The species *S. contigua* and *S. sulphuripes* are visually similar but could be distinguished by taking a really close look at the thorax. If there is a yellow spot on the anepimeron connected to the katepimeron then it is probably *S. contigua* and if there is no yellow spot between these parts then it is possibly *S. sulphuripes* (Balaban et al., 2018b.).

Male *Sphaerophoria* genitalia is usually large, globose, and parallel to the abdomen (Fig. 23a) (Miranda et al., 2013). The females in this genus (Fig. 23b) resemble species in *Toxomerus* but they lack triangular notches on the eye and distinct abdominal patterns. *Sphaerophoria* can also be characterized by the reduced to no hair under the scutellum and the rectangular 4th abdominal tergite (Miranda et al., 2013).



Figure 23a. Male *S. contigua* displaying thin and straight abdomen with globose genitalia. From Gary Mc Donald 2010.



Figure 23b. Female *S. contigua* displaying a darker color morph and broader abdomen. From University of California Santa Cruz.

***Sphaerophoria* (continued)**

Local plants where you could find *Sphaerophoria*

The specimen that were collected off a plant appeared to prefer yellow and white flowers. The most visited flower was coyote brush (*Baccharis pilularis*), followed by the flower tidy tips (*Layia platyglossa*). Other commonly visited plants in the Santa Cruz county included: telegraph weed (*Heterotheca grandiflora*), hairy gumweed (*Grindelia hirsutula*), and *Ericameria*

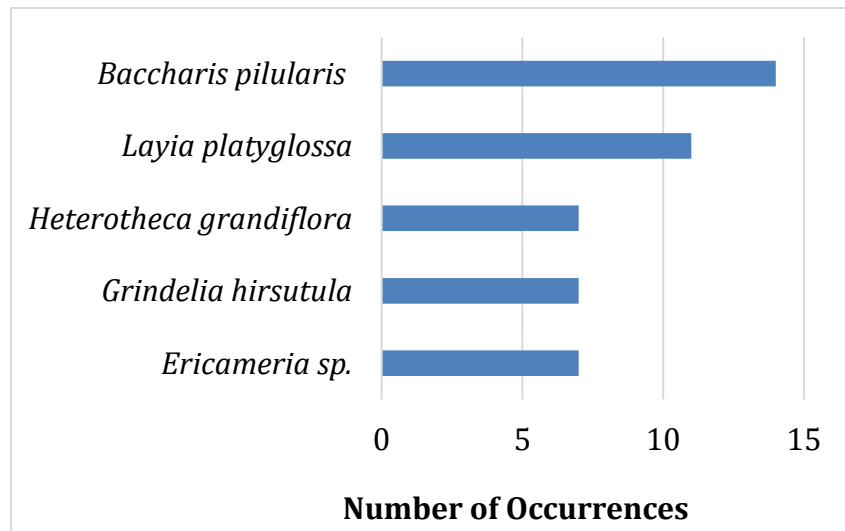


Figure 24. Plant species most visited by *Sphaerophoria* species from 1991-1999 in Santa Cruz County.

sp.

***Eupeodes*:**

Description and Identification Features

This genus can be confused with other members of its tribe, Syrphini. The size of *Eupeodes* ranges from 6.3-8.9 mm. Their feet and tibia are red/orange, wings have small irregularly scattered hair, and the eyes are almost hairless (Balaban et al., 2018c). A distinct characteristic from a similar genus like *Syrphus* is the black margined abdomen (Fig. 25b) (Balaban et al., 2018c).

Eupeodes has two very similar species *E. volucris* and *E. fumipennis*. The two can be differentiated by *E. volucris*' scutellum which has a yellow margin at the top with mostly short white hair (Balaban et al., 2018c). Individual *E. fumipennis* species are highly variable, some varieties have abdominal markings that meet in the center while others have single yellow bands across each tergite (Miranda et al., 2013). *E. volucris* however, shows no constriction between the two yellow bands.



Figure 25a. *E. volucris*. shows no constriction between yellow bands. From Gary McDonald 2008.



Figure 25b. Male *E. fumipennis* displaying strongly margined abdomen. From Gary McDonald, 2010

Local plants where you could find *Eupeodes*

The specimen collected from flowers mostly visited *Arctostaphylos sp.* and most occurrences on Manzanita. Other common plants were coyote brush and Monterey spineflower. This pattern is interesting because many other genera, showed their preferred plant was coyote brush.

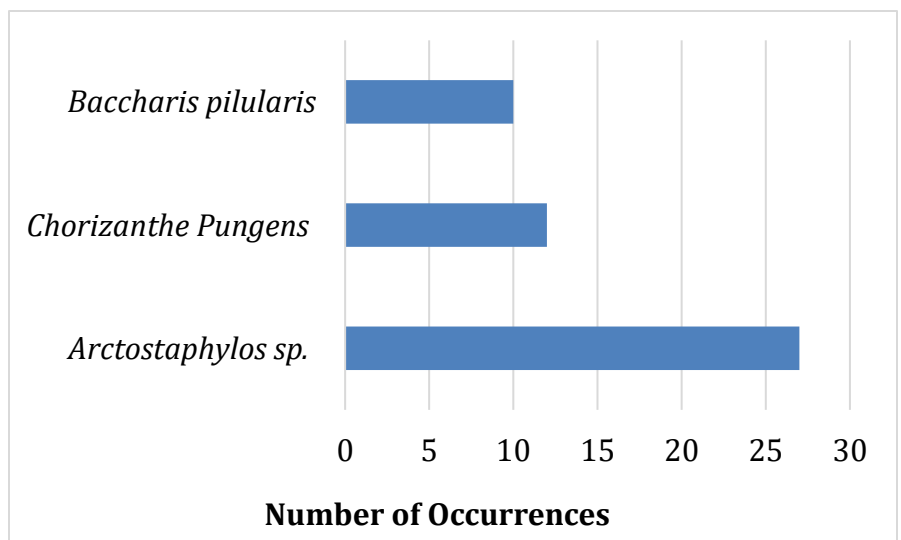


Figure 26. Plant species most visited by *Eupeodes* species from 1991-1999 in Santa Cruz County.

Tribe: *Toxomerini*

Toxomerus

Description and Identification Features

The species in *Toxomerus* are very small in size and are also quite common. The third, fourth, and fifth tergites usually have a pair of black stripes running down the middle of abdomen that may extend to the lateral sides on some species and for other species it may be mostly yellow with faded black stripes in the middle (Miranda et al., 2013). One very distinct feature that differentiates them from other genera is the triangular notches around their eyes.

T. marginatus and *T. occidentalis* are very similar but one sure way of differentiating them is the former has a margin of uninterrupted yellow around the abdomen (Fig. 27a) whereas the abdominal margin for *T. occidentalis* is interrupted yellow and black (Miranda et al., 2013). The scutellum on *T. occidentalis* is black with a yellow margin and the female specimen (Fig. 27b) has a broad abdomen and extended ovipositor.

Local plants where you could find

Toxomerus

This genus highly preferred coyote brush flowers, with more than 70 occurrences. Other highly visited plants include the California buttercup (*Ranunculus californicus*) and golden bush (*Ericameria* sp.).



Figure 27a. *T. marginatus*, displaying uninterrupted yellow abdominal margin. From Even Dankowicz 2005.



Figure 27b. Female *T. occidentalis* displaying broad abdomen and extended ovipositor. From Gary McDonald, 2008

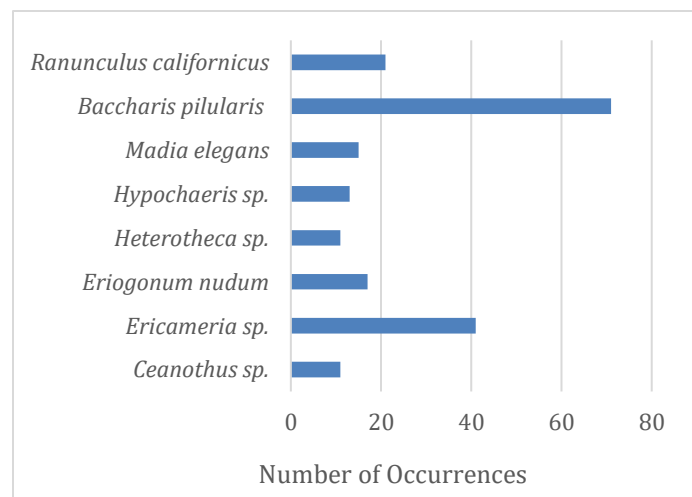


Figure 28. Plant species most visited by *Toxomerus* species from 1991-1999 in Santa Cruz County.

Syrphidae Occurrences in Santa Cruz County by Month (1991-1999)

Eristalis

In RMIC *Eristalis* is the most abundant and represented genus with over 750 occurrences from 1991-1999. The most abundant species include: *E. tenax*, *E. hirta*, *E. arborustrum*. This genus has a similar distribution to other abundant genera like *Eupeodes* and *Toxomerus*. According to RMIC data, species in *Eristalis* seem to occur year-round but with very few occurrences in January and December, an increase in May, and the most abundant in August, September, and October. This data can suggest that *Eristalis* species found in this county may prefer the warmer months in late summer and early fall.

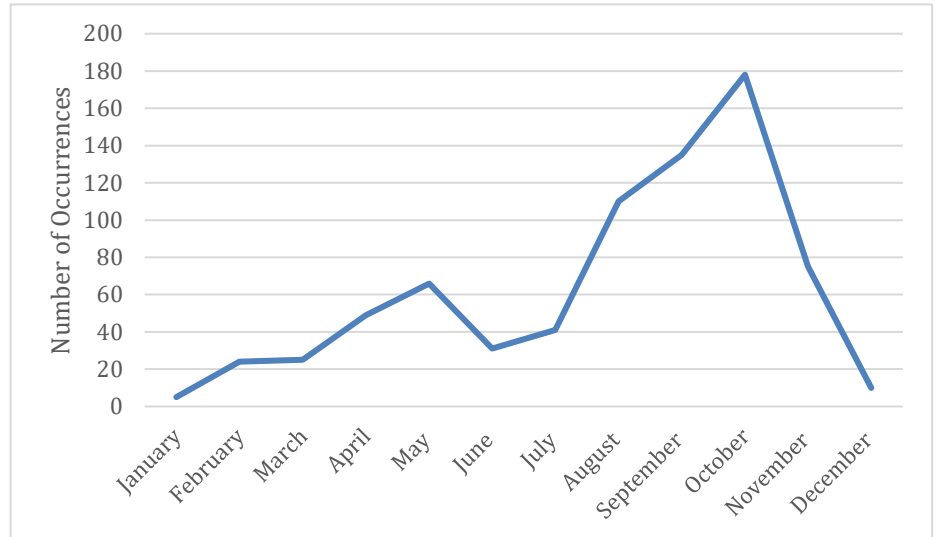


Figure 29. Monthly distribution of *Eristalis* from 1991-1999 in Santa Cruz County.

Merodon

In the RMIC, *Merodon* occurred 26 times throughout the 8 years. They were most abundant March to June, which are the bright and beautiful spring months following the winter rains in Santa Cruz.

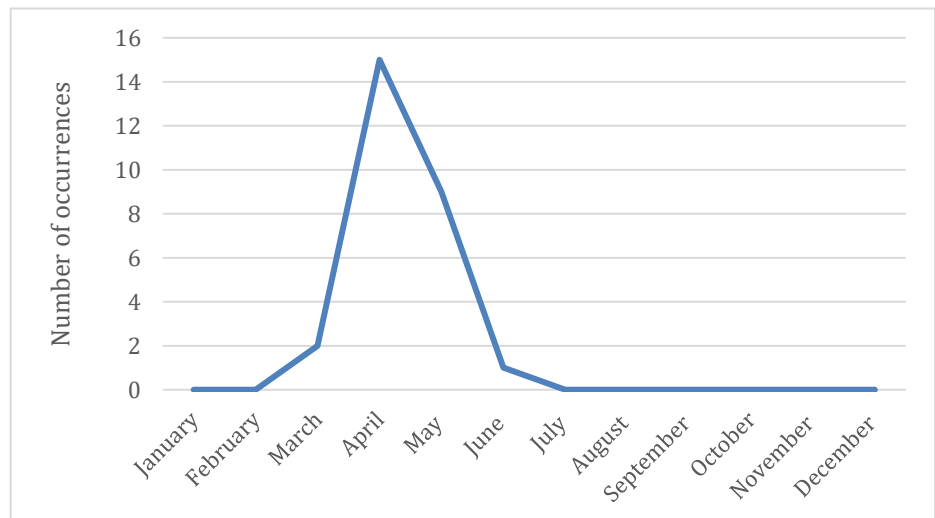


Figure 30. Monthly distribution of *Merodon* from 1991-1999 in Santa Cruz County

Sphecomyia

In the RMIC this species was only collected on three occasions between 1991-1999. Although we cannot necessarily find conclusive patterns from this data, it is important to note the time of year when the specimen were collected. There were two occurrences in February which is generally

a chillier time of the year and one specimen was collected in April which is the time of year where we start to see the sun again. This genus may be more cold hardy than other genera that do not occur during this time of year.

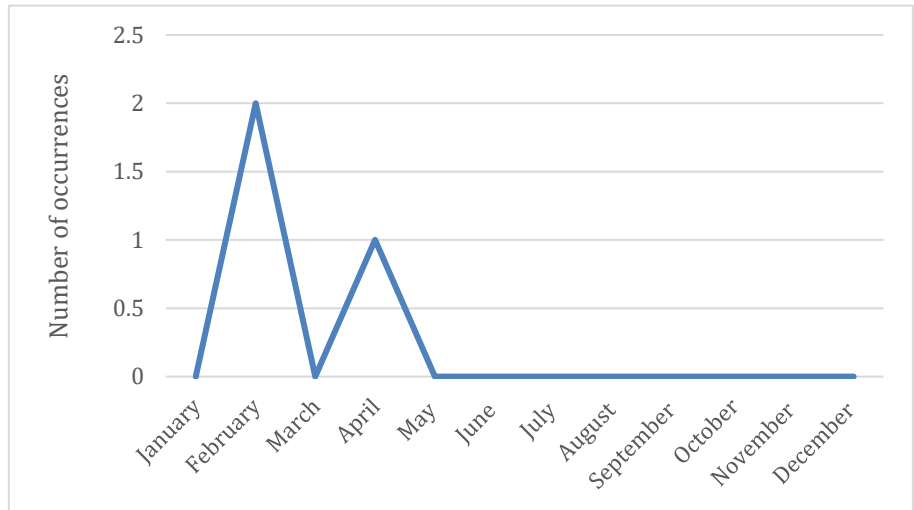


Figure 31. Monthly distribution of *Sphecomyia* from 1991-1999 in Santa Cruz County

Spilomyia

In the RMIC *Spilomyia* was collected 25 times throughout this eight-year period from 1991-1999. Most of these occurred during Santa Cruz's warmer months towards the end of July and the entirety of August and September. The numbers decline in October which is around the time temperatures start to drop.

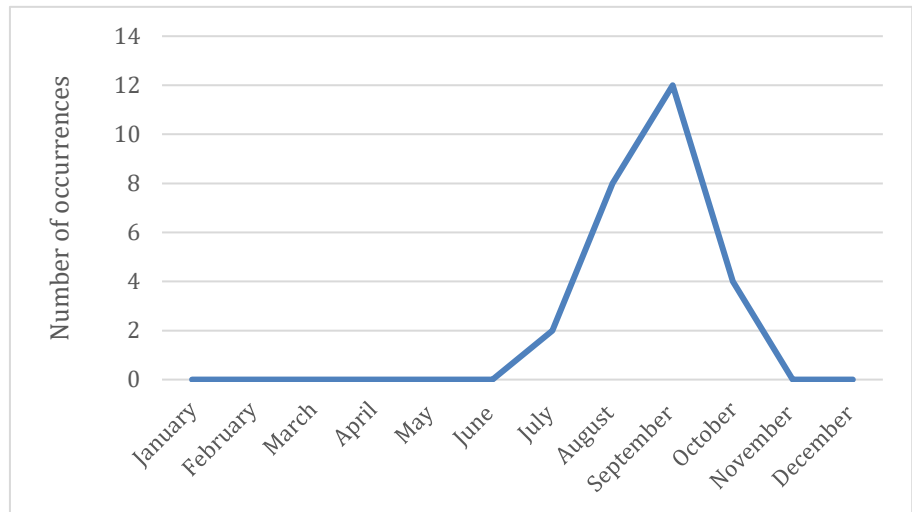


Figure 32. Monthly distribution of *Spilomyia* from 1991-1999 in Santa Cruz County

Copestylum

In the RMIC data we see six occurrences throughout the eight years of the collection. One happened in September, four in October, and one in November. The highest abundance in October can suggest a preference towards this time of the year.

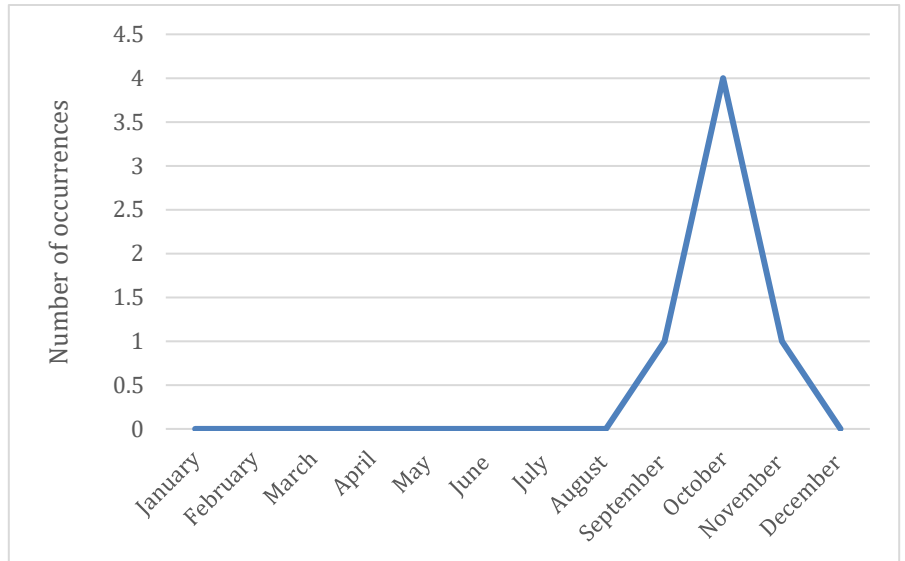


Figure 33. Monthly distribution of *Copestylum* from 1991-1999 in Santa Cruz County

Volucella

The RMIC data represents over eight years of collecting, but there is only one record of a *Volucella* species. This occurred in March (1995) which is a time of year where abundant genera like *Eristalis* and *Eupeodes* are not as plentiful.

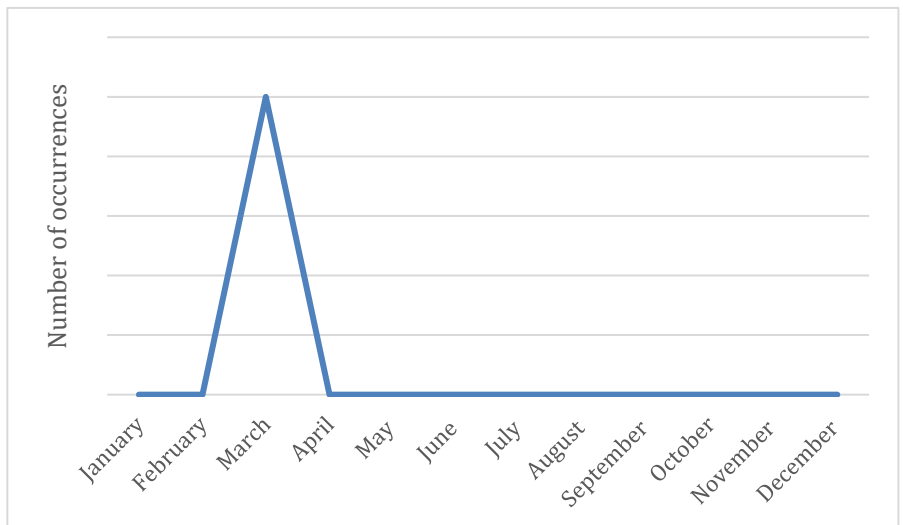


Figure 34. Monthly distribution of *Volucella* from 1991-1999 in Santa Cruz County

Syritta

In the RMIC *Syritta* represents 112 occurrences throughout the eight years. The most abundance is concentrated from July to October with the highest frequencies in August and September. These are generally the warmest months of the year in the Santa Cruz area.

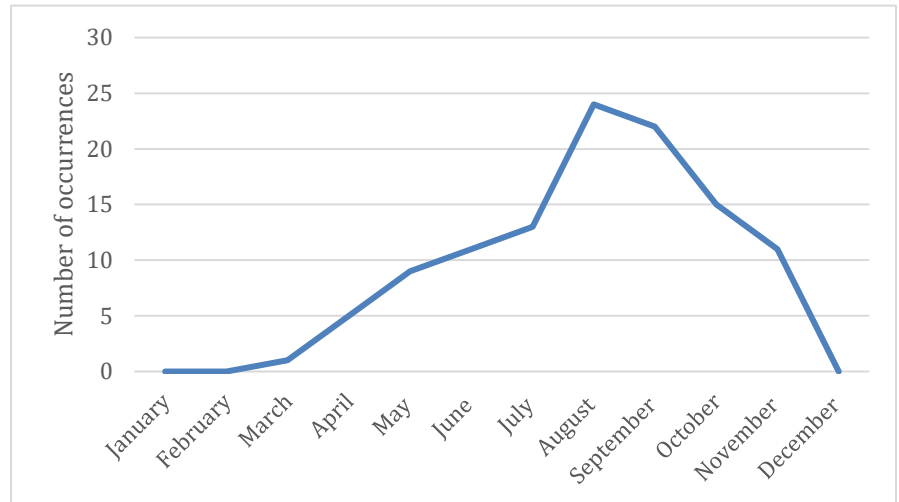


Figure 35. Monthly distribution of *Syritta* from 1991-1999 in Santa Cruz County

Allograptia

RMIC represents ~175 occurrences of *Allograptia* from 1991-1999. The most abundant species included: *A. obliqua* and *A. exotica*. After the peak abundance in February, there was a strong decline until the exponential growth in July. The longest period with high frequencies begins in September and carries on through November which is a trend seen in other genera as well.

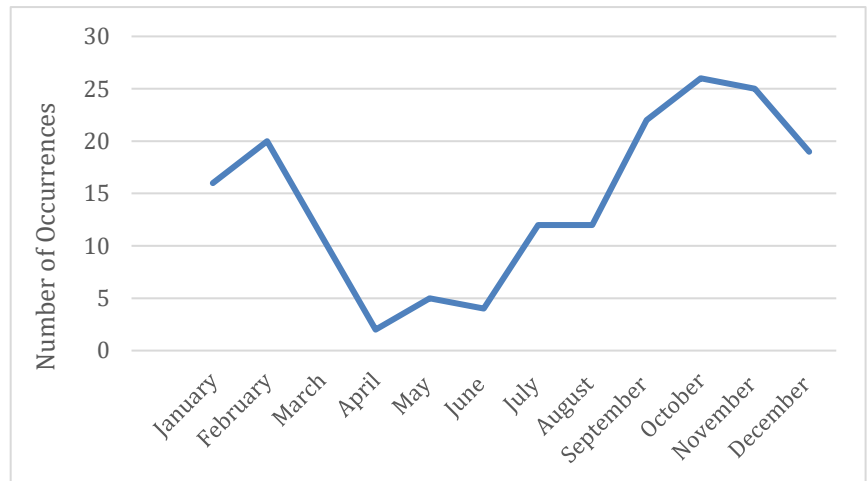


Figure 36. Monthly distribution of *Allograptia* from 1991-1999 in Santa Cruz County

Syrphus

RMIC represents 182 occurrences of the genus *Syrphus* and mostly the species *S. ribesii* and *S. opinator*. The 1991-1999 monthly distribution graph displays an interesting pattern as it peaks in March and November. The high abundance during October, November, December could suggest they prefer lower temperatures.

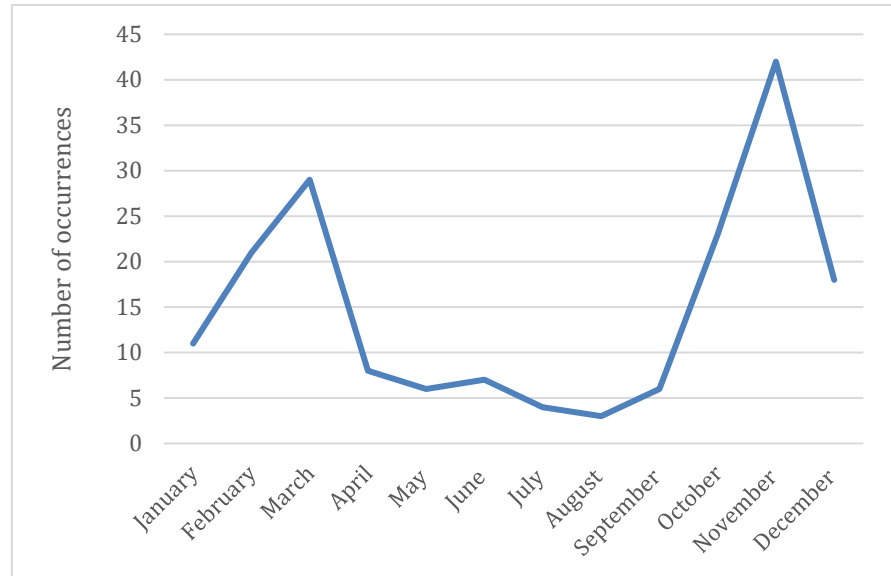


Figure 37. Monthly distribution of *Syrphus* from 1991-1999 in Santa Cruz County

Dasysyrphus

Though there are only six occurrences of this genus in the RMIC, there is an interesting pattern in the months when these specimens were collected. Two occurrences in April of 1991 and one occurrence in April of 1992 and 1993. Then, in 1995 and 1996 there was one specimen recorded in May of both years. Thus, a lack of abundance does not necessitate a lack of presence, though there were not several flies collected, their presence was noted during the peak of spring blooms.

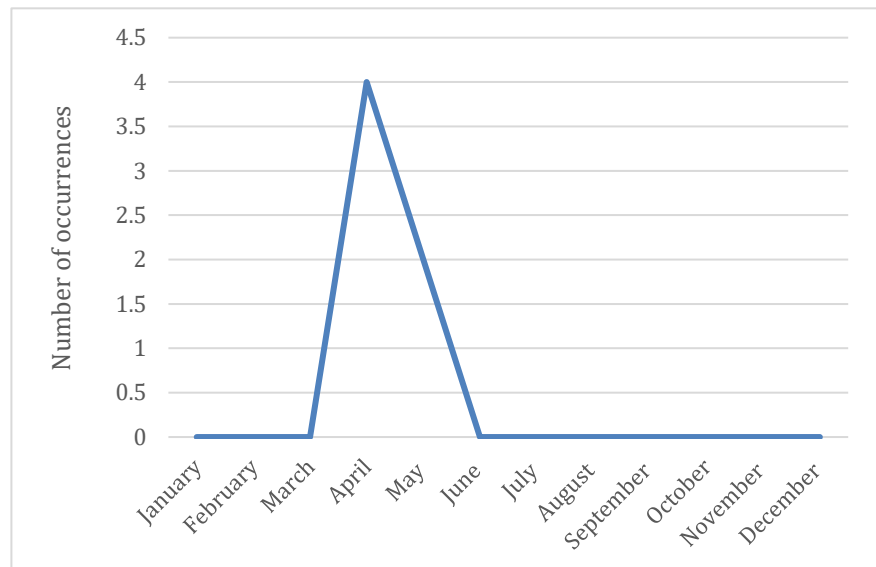


Figure 38. Monthly distribution of *Dasysyrphus* from 1991-1999 in Santa Cruz County

Lapposyrphus

RMIC represents 14 *Lapposyrphus* occurrences. The unusual pattern in the graph is due to the lack of specimen collected in March. There were three collected in January, February, and April. Then, July through October there is a lack of occurrences. This might suggest that *Lapposyrphus* tend to emerge in the earlier half of the year.

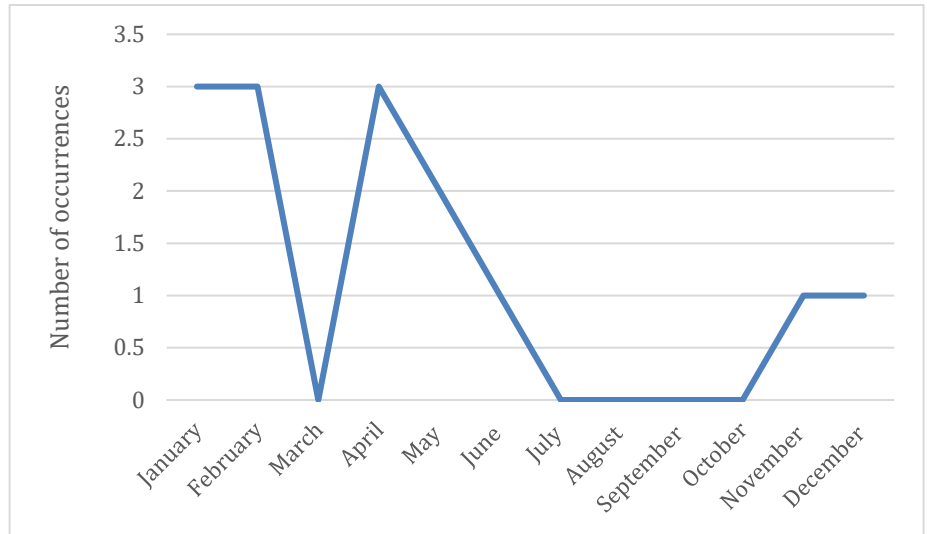


Figure 39. Monthly distribution of *Lapposyrphus* from 1991-1999 in Santa Cruz County

Scaeva

RMIC represents at least one occurrence for each month throughout eight years. Occurrences begin in January and carry on through December. Peak abundance occurred in April and May. After June, *Scaeva* is much less present and clearly shows a drastic decline in numbers.

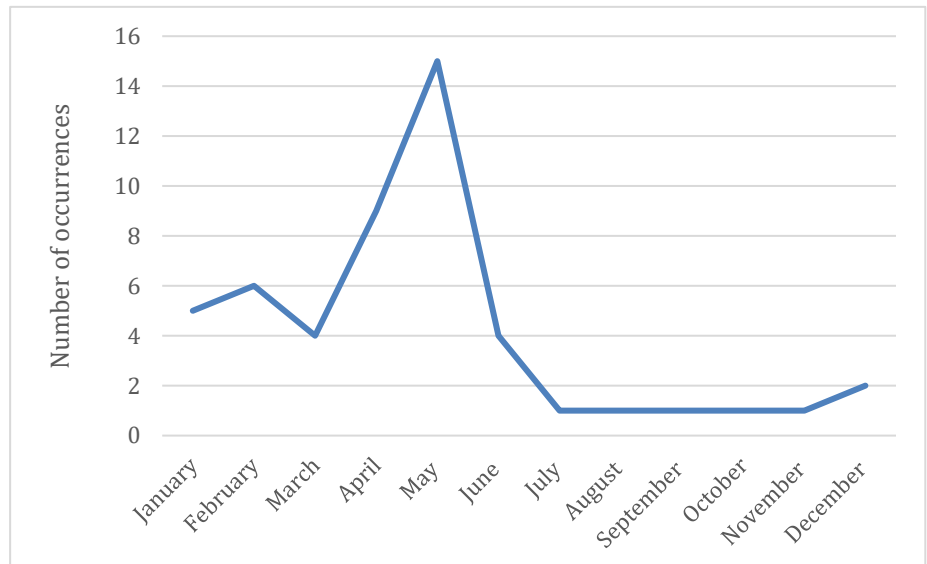


Figure 40. Monthly distribution of *Scaeva* from 1991-1999 in Santa Cruz County

Sphaerophoria

In the RMIC, *Sphaerophoria* represents a higher abundance than other members of the Syrphini tribe. The graph displays an interesting bell curve shape. This shows there are few to no occurrences in the beginning and ending months of the year, which generally have the lowest temperatures.

There is a greater abundance for the months in the middle. March through October hosted the most occurrences with the peak abundance in June.

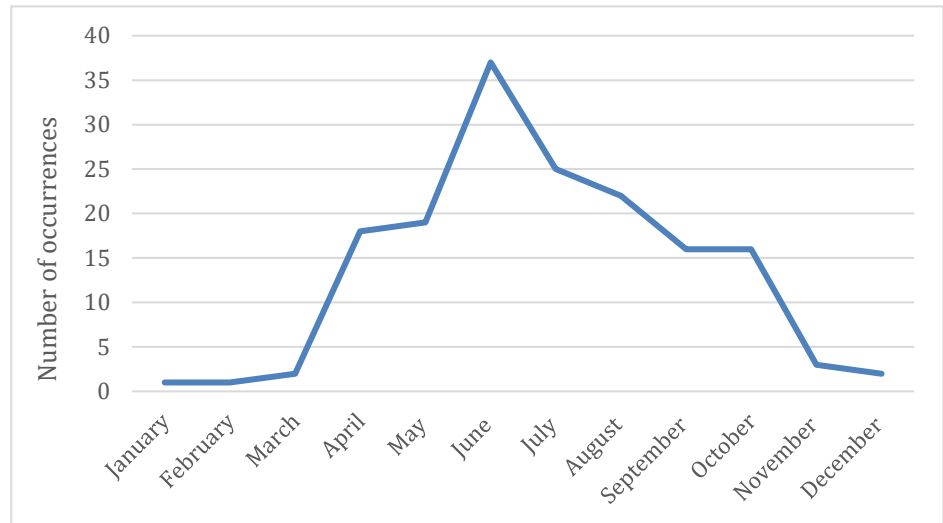


Figure 41. Monthly distribution of *Sphaerophoria* from 1991-1999 in Santa Cruz County

Eupeodes

Eupeodes is widely represented in RMIC, with over 300 occurrences throughout the eight-year sample period. Unlike other highly abundant genera in RMIC, which seem to prefer August- October, *Eupeodes* is not as abundant during this time. Instead, this genus seems to prefer January- July with a peak in May. There is a strong decrease in abundance from July to September and then the numbers pick up in November and December.

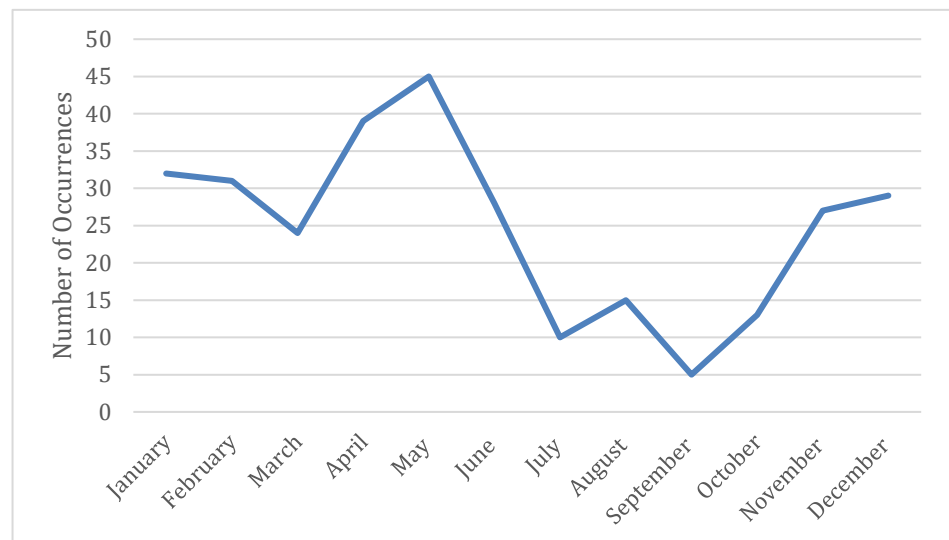


Figure 42. Monthly distribution of *Eupeodes* from 1991-1999 in Santa Cruz County

Toxomerus

Toxomerus, the second most abundant genus in RMIC represents over 430 occurrences. This genus is not very present in December and January but has a steady population throughout February and August. Similar to the most abundant genus, *Eristalis*, *Toxomerus* also has a peak abundance in October.

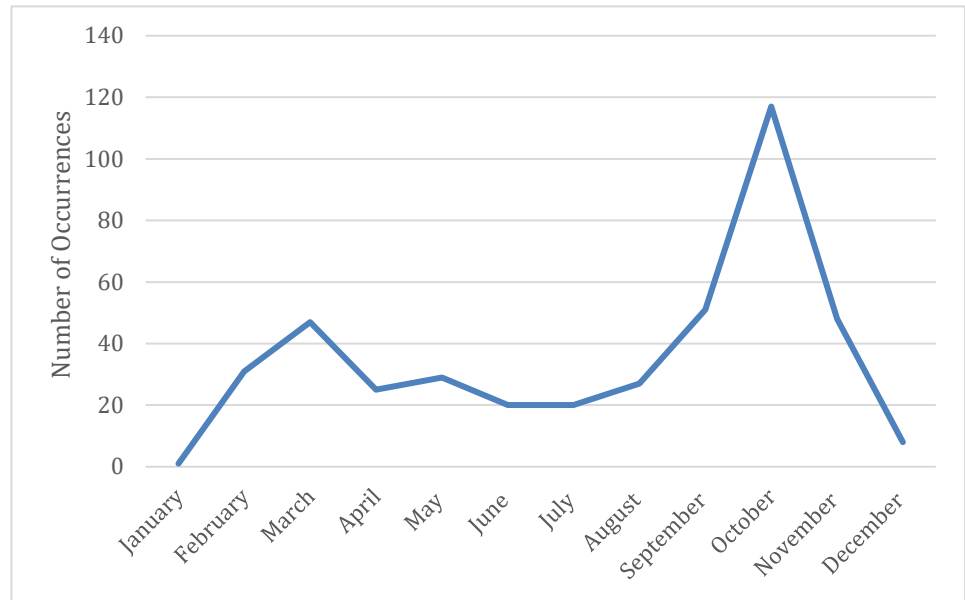


Figure 43. Monthly distribution of *Toxomerus* from 1991-1999 in Santa Cruz County

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