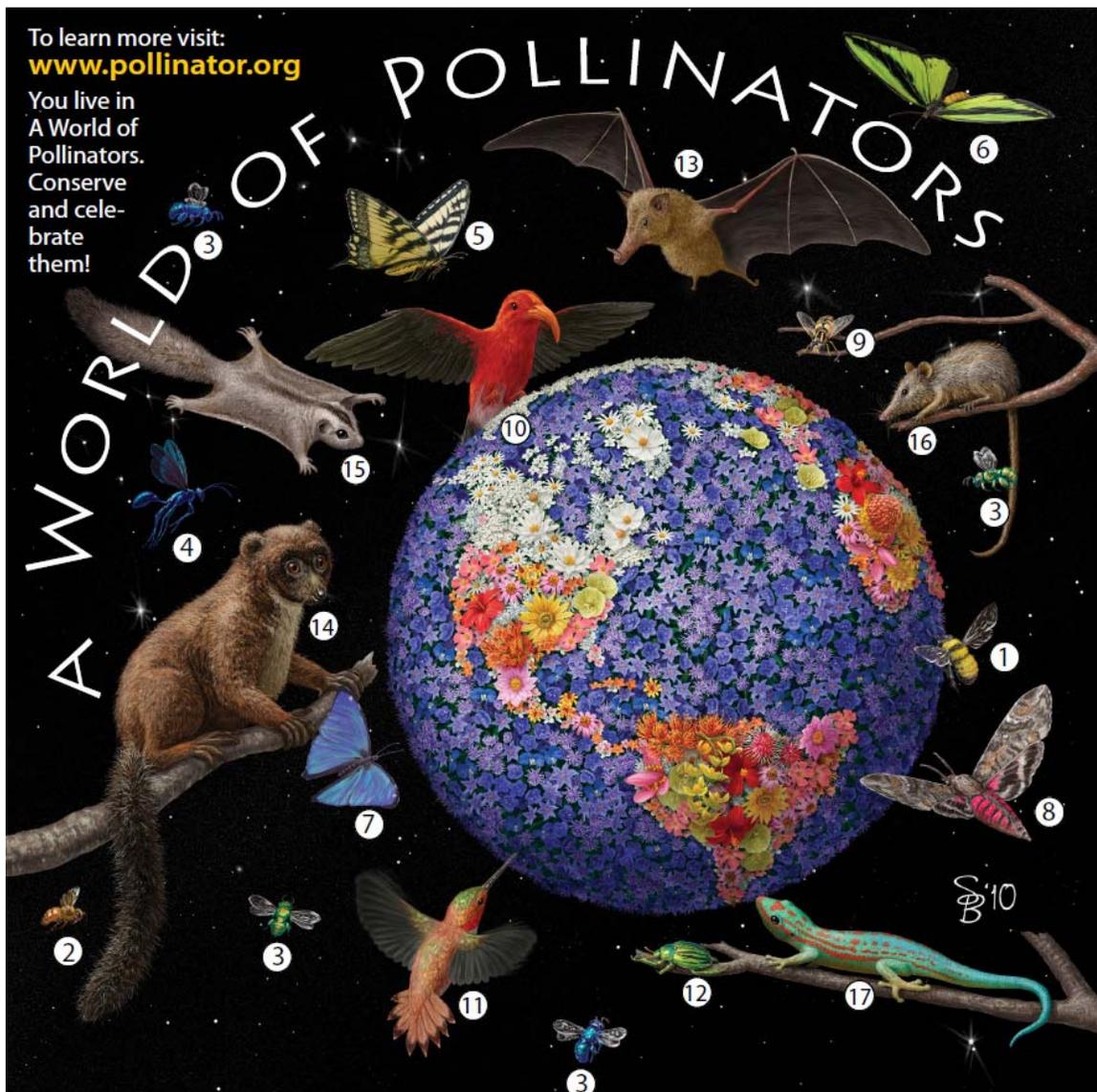


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1.) Bumble bee (*Bombus sonorus*)

This western bumble bee is large and bright with rich black and yellow hairs. It can be found in southern California, several other western states and northern Mexico. Like all bumble bees (about 250 species), they live underground in annual colonies started by an overwintered queen in the spring. Colonies consist of a few hundred individuals, usually in an old rodent burrow, mouse nest, or under a board or shed. Unlike several other western bumble bees, it does not seem to be declining in numbers in the wild. The genus *Bombus* excel at something honey bees can't do, buzz pollinate, the sonication of flowers with pored anthers including tomato and eggplant. This species is defensive of its nest and not a good candidate for greenhouse pollination services. One promising western bumble bee species, currently being investigated for commercial pollination (like *B. impatiens* in the eastern US) is *Bombus huntii*.

2.) The European Honey Bee (*Apis mellifera*)

Would it surprise you to learn that this most familiar of bees, and next to the fruit flies, one of the most studied of all insects, the European honey bee, isn't native to North America? These familiar golden brown and black striped honey-hoarders came bouncing across the Atlantic in sealed casks. They were first brought to the United States by the Jamestown colonists in 1621. So, honey bees have only been a part of our insect fauna for a little over four centuries. Swarms of honey bees were harbingers of advancing colonists making their way west, and were called "white man's flies" by the Cherokee. Make no mistake about it, female worker bees are an invaluable agricultural workforce. Today, there are about 2.2 million managed colonies (each with about 40,000 sisters, a queen and a few hundred males, the drones), and perhaps a million or so rented for the pollination of more than 100 major US agricultural crops, including almonds grown in CA. Through their pollinating activities honey bees contribute \$8-10 billion annually to the US economy, with an additional \$3 billion contributed by many of the 4,000 native bees, nesting in soil, twigs or solid wood. Today most commercial beekeepers make a living by negotiating pollination contracts with growers rather than producing that sweet stuff, honey. Unfortunately, honey bees seem to have a naturally compromised immune system. You may have heard about Colony Collapse Disorder (CCD) which has been affecting honey bees in the US and elsewhere, causing dramatic population declines since 2006. CCD seems like a "perfect storm" for bees, and likely due to numerous causes rather than one factor, which may include poor nutrition, parasitic mites, bacterial and viral diseases, stress, and exposure to various agricultural chemicals.

3.) Orchid Bees (*Euglossa imperialis* and *Euglossa cf. mixta*)

These living jewels of the rainforest come in shiny metallic colors, greens, blues, reds, and brassy gold. They can be found a few hundred miles south of the US border and through Mexico, meso American and into South America as far south as Argentina. One species, *Euglossa viridissima* is even a naturalized species in parts of Florida. These bees have extremely long tongues (proboscides) which in some species are several times longer than their bodies. They are characteristic bees of deep green multi-storied rainforests, especially Panama,

Colombia and the Brazilian Amazonian forests. Females visit different kinds of flowers than the males. Male euglossines seek out tubular flowers with dilute nectar. Males are champion pollinators of certain tropical orchids. Orchids produce hidden and “shrink-wrapped” pollen in packets, which they glue to different body regions of one or more orchid bee species. Male orchid bees spend weeks exhaustively harvesting terpenes, alcohols and other fragrant chemicals from orchids which otherwise offer no food rewards. The bees store these fragrances in enlarged hind leg glands. Later, they use them in ways we don’t completely understand to attract females for courtship and mating. Thanks to the ease with which these bees come to (“baited in”) synthetic orchid fragrances like cineole (eucalyptus scent), vanillin (the vanilla odor) and others, they have become more available for study by taxonomists and ecologists in the past several decades. Orchid bees are in the same family, Apidae, as the more familiar honey bees and bumble bees.

4. Wasp- The Blue Mud Wasp (family Sphecidae, *Chalybion californicum*)

This is a very widespread wasp living in most of the United States and into Mexico. Its shiny metallic blue body gets noticed. Superficially, it looks like, and is confused with the spider wasps or pompilids. They areinquilines inside the nests of more common mud wasps, the familiar black and yellow mud dauber, *Sceliphron cementarium*. *Chalybion* stocks its nest with spiders, and has been seen using black widow spiders as prey items. Leggy sphecid wasps in the family Sphecidae, or digger wasp family, are good pollinators of some plants, especially milkweeds, where they can often be seen alongside others like the real pompilid spider wasps. Only a few wasps have one-on-one obligate relationships with plants, as the case for fig wasps.

5.) Butterfly- The Eastern Tiger Swallowtail (*Papilio glaucus*)

The Eastern Tiger Swallowtail is a familiar yet beautiful butterfly found in the eastern United States as far north as Vermont and to the west, ranging into eastern Colorado. Many a child, a budding entomologist has caught one in the folds of a net, or seen their large (up to 11 cm across) striped black and yellow wings sipping nectar from a milkweed, thistle or other garden or roadside plant. There are two types (morphs) of the females. In the southern US, there is a black form without the broad expanses of yellow. Males are tiger-striped in both geographic regions. Their larvae feed on tulip tree, lemon and cherry leaves. Young caterpillars sit quietly and resemble bird droppings. Mature larvae take on even more amazing camouflage, they rear up and reveal a snake’s head pattern (like a Hognose snake). This disguise often fools hungry birds or other predators. If harassed further, they will evert a smelly orange gland, the osmeterium, which usually effectively repels attacks by small animals. Their strong wings carry them from flower-to-flower sipping nectar, and dispersing pollen grains on their legs and soda straw like tongues along the way.

6.) Butterfly- Cairns Birdwing (*Ornithoptera priamus*)

These butterflies held the co-discoverer of evolution, Alfred Russell Wallace, in awe as he caught them during his travels across Papua New Guinea. They are some of the largest, and most beautiful butterflies in the world. These are tropical giants in the same family, the swallowtail family Papilionidae, as the more familiar temperate members include black and tiger swallowtails.

In the case of *Ornithoptera alexandrae*, the wingspan can be 11 inches. All birdwings live in Asian rainforests. The adults seek out nectar-bearing flowers in the upper canopy and also frequent terrestrial flowers including *Lantana*. As such, they are long-distance vectors of pollen, important pollinators. Their large caterpillars feed voraciously on the usually poisonous leaves of the Dutchman's pipe (*Aristolochia*) genus. They are a favorite in many butterfly house exhibits. All birdwing species are listed in Appendix II and protected under CITES. *Ornithoptera alexandrae* is totally protected (Appendix I and considered endangered).

7.) Butterfly- The Menelaus Blue Morpho, male, (*Morpho menelaus*)

Along trails and roadsides in the American tropics you may be privileged to catch a fleeting glimpse of an amazing butterfly, with a broad wingspan of six inches. There is nothing else like the brilliant iridescent blue flash of its wing scales, colors produced without pigments but due to the fine spacing of tiny parallel lines on the upper surface of its millions of wing scales. Many *Morpho* males are bright blue while their females are somewhat drab. Usually, they are denizens of the upper canopy and out of reach. The adults visit flowers for nectar but are more commonly seen sipping juice from rotting, often fermenting fruit on the ground. This is about the only way to entice them down for a closer look. They have often been observed feeding at dead animals or excrement. They are found in southern Mexico, Central American and tropical South America, especially Venezuela and Brazil. Scientists place these beauties in the brush-foot family, the Nymphalidae (about 5,000 species worldwide), along with more common butterflies, of the US, including red admirals and buckeyes. Male morphos have long been prized by collectors and are jaw-droppers in butterfly houses around the world. In flight they are unmistakable, but quickly disappear when they land and fold their wings up erect over their bodies. In addition to dispersing pollen of certain blossoms, they often visit fungi and may effectively disperse fungal spores.

8.) Moth, The Pink-spotted hawkmoth or sphinxmoth (*Agrius cingulata*)

This magnificent hot pink moth is a member of the large hawk moth family (Sphingidae) with about 1,200 species worldwide. Their broad wings can be up to 4.75 inches across. There are quite a few of these moth species in the United States, including the all too familiar tomato hornworm, but they are most common in tropical regions. Most are accomplished aerialists able to hover, quickly dart or even fly backwards. When foraging for nectar, they are commonly mistaken for hummingbirds in gardens. *Agrius* adults are nocturnal, like most hawk moths, and feed on the nectar of fragrant white blossoms including moonflower, various morning glories or cultivated petunias. Their large caterpillars have the characteristic spine (horn) at the end of the abdomen and may rear up into a "sphinx" posture when disturbed. Their larvae feed on plants including sweet potato or jimsonweed. Adults have very long tongues, proboscides, which allow them to reach far in the throats of moth-pollinated blossoms to reach the hidden nectar. They are very strong fliers and excellent transporters of pollen between unrelated kin of the same flowering plant species, making them efficient and dependable pollinators of many flowering plants. Entomologists use strong mercury vapor lights to attract them and other moths at night. They were also one of the first insect groups demonstrated to be "warm blooded." On cold nights, they shiver their powerful flight muscles in order to fly, warming and revving up the flight engine.

9.) Fly, a syrphid or flower fly (*Helophilus pendulus*)

Helophilus pendulus is a hoverfly, also known as a flower fly, common to Britain. Its scientific name means “dangling swamp-lover.” It is a very common species and can be seen hovering, darting and alighting at flowers in gardens, pastures and meadows. It is associated with bodies of water, including large lakes and rivers down to ditches and mud puddles. The larvae are aquatic and feed on detritus. Other syrphid larvae are terrestrial and feed upon aphids or thrips, making them popular as biological control agents with gardeners and farmers. Like other flower flies, *Helophilus* is commonly seen in gardens where it basks in the sun on leaves or feeds on flowers for both nectar and pollen. Females of these flies must feed on pollen in order to lay their eggs. Flower flies, the family Syrphidae, are a very large group of flies around the world. At least 6,000 flower fly species are found in some 200 genera worldwide. Mimicry is common among flower flies. The adults, while foraging for nectar and pollen, may look and act like bees or wasps. Some of them even have wingbeats that sound like bees. Their characteristic black and yellow striped bodies gave them a bee or waspish appearance. Presumably this mimicry gives them protection from visually hunting predators like birds or lizards. A study published in the journal *Science* by members of the ALARM research group in England found over a 20 year period in British and Swedish study plots that native bees and flower fly species had dropped drastically by 40-60% in some cases.

10.) Birds- Scarlet Hawaiian Honey creeper, the 'I'iwi (*Vestiaria coccinea*)

This outrageous fiery red bird with black wings is a native Hawaiian finch, in the group known as honeycreepers. It can be found commonly on the islands of Hawai'i and Kaua'i, along with Moloka'i and O'ahu. This species has a salmon-colored bill which is curved downward. It is a plentiful member of a group (honeycreepers) formerly common in the Hawaiian islands but since ravaged by habitat loss (as lands have been cleared for farming, grazing and housing), predators and avian malaria. For the 'I'iwi there may be as many as 350,000 birds in remaining populations. Its status is now considered vulnerable. This bird has become a highly recognizable symbol of Hawaii. The 'I'iwi originally drank nectar from, and pollinated, many types of native lobelioid flowers, especially the genus *Clermontia*. These flowers have declined drastically, and the 'I'iwi switched to foraging from the more common 'ohi'a lehua (*Metrosideros polymorpha*) trees. The birds also catch and eat small insects. In historical times, its feathers were used by Hawaiian nobility for their crimson robes and ceremonial helmets.

11.) Birds- the Rufous hummingbird, SW USA, (*Selasphorus rufus*)

Along with hummingbirds, honey creepers, white eyes and sunbirds are examples of flower-visiting specialist birds in other parts of the world. Even some songbirds, migratory warblers get in on the act and move the pollen around when they visit flowers for nectar or search for insect prey. The Rufous hummingbird is a small hummingbird about 8 cm long with a long straight slender bill. Adult males have rusty plumage on the face flanks and tail but with a white breast. Males have a brilliant iridescent orange-red throat patch, the gorget. The female has green upper plumage and white underneath. These birds breed in open areas and forested edges, ecotones, from southern Alaska to California. They actively migrate long distances

following their nectar corridors. Many birds fly through the Rocky Mountains and neighboring lowlands in summer months to take advantage of numerous blooms suited to them, often yellow, orange or red tubular blossoms with dilute nectar. These tiny birds, weighing only 3 or 4 grams, may travel 2,000 miles and many winter in forested areas of Mexico, especially the state of Guerrero. A hummingbird marked by the late ecologist, William Calder, lived to be 7 years old. Although they are predominantly nectar feeders, they catch small insects on the wing or near their floral hosts. Male birds set up and aggressively defend territories near their food plants.

12.) Scarab beetle (*Plusiotis gloriosa*, or sometimes known as *Chrysina gloriosa*)

Although not a champion pollinator itself, the incredibly striking green and metallic silver-striped Arizona and Mexican beetle, other scarabs are common floral visitors. We chose *P. gloriosa* to represent flower-visiting beetles in the scarab, the Scarabaeidae family. They are about 1 inch long and notable for the shiny silver stripes on the wing covers, the elytra. Adults feed on juniper leaves and camouflage themselves amongst the juniper boughs. The family Scarabaeidae is a huge one, with over 30,000 recognized species worldwide. They are commonly called scarabs. The iconic Egyptian scarab (*Scarabaeus sacer*) known from tomb jewelry is an example of this family. The C-shaped larvae, known as grubs, are pale yellow or white and the familiar grubs found in the soil living among grass roots in lawns. Most of the scarabs are nocturnal as adults, but many daylight active species are flower-visitors. The flower chafers (Cetoniinae) and leaf chafers (Rutelinae) are commonly found in flowers. Many smaller beetles including tumbling flower beetles, rove beetles, certain longhorned wood-boring beetles, and others are important pollinators, especially in tropical regions of the world. Beetle pollination is often referred to as “mess and soil” pollination since these beetles find flowers to be excellent pantries, hideaway shelters and places to mate. Flowers including Magnolias, tulip trees and spicebush have numerous floral parts and often feeding tissue adapted to the beetle’s not-so-delicate floral visits.

13.) Banana bat (*Musonycteris harrisoni*)

This handsome long-nosed tropical bat is found in isolated regions along the western coast of Mexico. They have an extremely long face. It is the only member of its genus, and placed in the leaf-nosed bat family, the Phyllostomidae. They live in arid thorn and tropical deciduous forests regions in the Mexican states of Colima, Guerrero, Jalisco, Mexico and Morelos, and never above 1,700 meters elevation. They are becoming highly endangered since their native habitats are now threatened by habitat loss and land conversion to agriculture and other uses. The banana bat has an extremely long tongue (up to 76mm long) and very tiny teeth, like many leaf-nosed bats which have evolved adaptations for specialized feeding on flowers. These bats have special branched hairs on their necks which may be an adaptation to holding onto pollen from their host flowers. Due to their strong flight, banana bats are excellent long distance pollinators. In undisturbed forests, these bats have been observed feeding from flowers of the kapok tree, *Ceiba grandiflora*. The bats have been captured in banana plantations and also roosting in culverts and caves.

14.) The Red-Bellied Lemur (*Eulemur rubriventer*)

Other than certain bats, and the sugar gliders and honey possums, non-flying mammals are unlikely pollinators. Lemurs are medium-sized (up to 40 cm long not counting the long tail) prosimians endemic to the giant island of Madagascar. The red-bellied lemur lives in rainforests in eastern Madagascar and has been studied in Ranomfana National Park. Males are distinguished by the teardrop-shaped patches below their eyes. The fur is deep rich chestnut brown. They have been designated as vulnerable by the IUCN, mainly due to threats from slash-and-burn shifting agriculture in habitats where they live. It is considered to be a fruit eater, but also feeds on leaves, nectar and flowers. Red-bellied lemurs have been seen visiting, and presumably pollinating, the flowers of *Vahimberona*. Recently, it has been observed feeding on flowers of the introduced guava, *Psidium littorale*. A relative, the black and white-ruffed lemur is believed to pollinate the traveler's palm (*Ravenala*) and possibly other plants including *Brexia* and *Parkia*.

15.) Sugar glider (*Petaurus breviceps*)

This cutie with gray fur, big eyes and striped head is a small gliding marsupial from Australia. These mammals leap from tree branches and glide much like flying squirrels do in other parts of the world. Sugar gliders live in eastern and mainland Australian, New Guinea and the Bismarck Archipelago. There are seven species of sugar gliders. They live in trees in family groups of up to 7 adults. They are active at night and hunt for insects and even small vertebrates. They are also attracted to and feed upon oozing sugary sap of certain tree species in the genus *Eucalyptus*. A relative, the yellow-bellied glider, *Petaurus australis*, feeds on the nectar of *Banksia* and *Eucalyptus* in Australia.

16.) The Honey possum (*Tarsipes rostratus*)

The honey possum (*Tarsipes rostratus*) or "Noolbenger" is a very tiny mammal weighing only 7 to 16 grams and with a body length of 7 to 9cm. Some insects are larger and heavier than this mammal. It has no close relatives. It is the only member of its genus and of the family Tarsipedidae. Its geographic range includes the southwest of Western Australia, and appears to be locally common in habitats of heath and woodland. It is one of the very few entirely nectarivorous animals. It has a long pointed snout and a long, extensible tongue. The tongue has a brush-like tip used to gather pollen and nectar. Other nectar-feeding animals with brush-tipped tongues include hummingbirds, honeyeaters and some bats. Honey possums are usually nocturnally active and spend their days sleeping in rock crevices or in tree hollows. They feed upon the pollen and nectar of native Australian plants including *Banksia* and *Adenanthos*.

17.) The Blue-tailed day gecko (*Phelsuma cepediana*)

Leaping Lizards, a lizard pollinator! Day geckos in the genus *Phelsuma* are active during the day unlike most other geckos. Many of them are extremely brightly colored with red and blues. They inhabit islands of the southwestern part of the Indian Ocean. Most species are found in Madagascar. They are arboreal hunters of small insects, consume fruit, and also adapted for visiting flowers of certain plants. The blue-tailed day gecko lives on the island of Mauritius. They are found on bushes and trees including traveler's palms, coconut palms, bananas and papayas in urban areas. Blue-tailed day geckos may be involved in a recent pollination relationship with a

highly Mauritius blossom, *Trochetia*. which was presumably pollinated by a now extinct bird, the Olive White-Eye? The blue-tails lick soft fruits, and also lick at flowers for pollen and nectar. On predator-free islands offshore New Zealand, there is another gecko that pollinates the native New Zealand flax when it's not gobbling down moths or wetas (large flightless crickets). This lizard, the Duvaucel's gecko (*Hoplodactylus duvaucelli*) even has modified throat scales, which may be an adaptation for transporting pollen. At flowers, however, it is only interested in licking up nectar. In all, scientists now know of about 50 species of lizards which serve as pollinators, a normally rare occurrence that seems to have evolved on islands, perhaps taking the place of more normal birds or mammals which may be absent. Shortages of arthropod food may also have led some lizards down the primrose path.