HAWAII TECHNICAL NOTE AND CONSERVATION PLANNING GUIDE 25

ANTHRICINAN YELLOW-FACED BEE (*HYLAEUS ANTHRACINUS*)

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Photographs & Artwork

Cover Photograph

Male *Hylaeus anthracinus* from Keoneoio, Maui, by Lahaina Photography.

CONTENTS

HYLAEUS ANTHRACINUS BIOLOGY

Scientific Name: *Hylaeus anthracinus* (F. Smith, 1853)

Common Name: Anthricinan yellow-faced bee

Phylum: Arthropoda
Class: Insecta
Order: Hymenoptera
Family: Colletidae
(Daly & Magnacca 2003; Michener 2007)

Synonyms: *Prosopis anthracina* (F. Smith, 1853); *Prosopis rugiventris* (Blackburn, 1886; Daly, 1994); *Nesoprosopis anthracina* (Perkins, 1899); *Hylaeus (Nesoprosopis) anthracinus* (Meade-Waldo, 1923); *Prosopis anthracina* (Daly, 1994)

Type Locality: This species was first described by F. Smith (1853) from specimens collected on the west coast of Hawaii at Kealakekua Bay.

CONSERVATION STATUS

US Endangered Species Act: Listed Endangered (30 Sep 2016) (USFWS 2016)

SPECIES SUMMARY

Yellow-faced bees (bees in the genus *Hylaeus*) are important pollinators of native Hawaiian plants. *Hylaeus anthracinus*, known simply as the anthricinan bee, is one of 63 described *Hylaeus* bee species endemic to the Hawaiian Islands—the only bees native to the islands. *H. anthracinus* is a rare yellow-faced bee, which is almost strictly a coastal species, found primarily in coastal strand habitat on the islands of Oahu, Molokai, Kahoolawe, Maui, Hawaii, and historically Lanai. It has also been found at higher elevations in dry forest on the island Hawaii; however, it is unknown if breeding populations exist in high elevation dry forest habitat. The primary threat to this species and other Hawaiian yellow-faced bees is habitat loss. Much of the native coastal habitat this species depends on has been degraded or lost largely due to development and nonnative plant and animal introductions. With native coastal habitat becoming increasingly rare, *H. anthracinus* populations are now limited to small patches of habitat. Nonnative ant introductions pose another significant threat largely due to their role as predators, but competition at flowers may be a significant issue as well. The anthricinan bee was federally listed as an endangered species in 2016, along with six other rare Hawaiian yellow-faced bees (USFWS 2016). Following federal listing protections for the bee, it is currently receiving considerable conservation attention, including recent studies to determine the success of artificial nests that protect nest sites from nonnative predators (Graham et al. 2015; 2016). In addition, this species is the subject of translocation and captive propagation studies, as well as habitat restoration projects to help promote foraging and nesting needs. Much of this recent research is ongoing and unpublished (e.g., a Smith Fellowship to study the genetics of *Hylaeus anthracinus* to inform future propagation work, and a Department of Defense Legacy Resource Management Program studying nest ecology to design conservation management methodologies). These studies will inform future conservation strategies but do not replace the need for carefully planned conservation practices, including habitat restoration, to recover populations of this species and other yellow-faced bees.

TAXONOMIC NOTES

Hylaeus anthracinus was originally described by F. Smith (1853) as *Prosopis anthracina*. The Oahu population was described by Blackburn (1886) as *Prosopis rugiventris*. In 1899, it was moved to a new genus *Nesoprosopis* by Perkins, who also synonymized the two names; during this time it was known as *Nesoprosopis anthracina*. *Nesoprosopis* was later reduced to a subgenus of *Hylaeus* by Meade-Waldo (1923). In 2003, Daly and Magnacca revised the basic taxonomy for native bees in the *Hylaeus* genus for the Hawaiian Islands. While *H. anthracinus* is the currently accepted name (Daly & Magnacca 2003) and it is treated as a single species, recent genetic evidence suggests it may represent multiple cryptic (not recognized) species or subspecies with distinct populations on the Hawaiian Islands where it is known (Hawaii, Maui + Kahoolawe, and Molokai + Oahu; Magnacca & Brown [2010]).

SPECIES DESCRIPTION

ADULT

Bees in the genus *Hylaeus*, which includes *H. anthracinus*, are commonly known as yellow-faced bees for their facial markings that are often yellow to white. The *Hylaeus* genus has a worldwide distribution; *H. anthracinus* is one of 63 described species found on the Hawaiian Islands (Daly & Magnacca 2003; Magnacca 2011; Magnacca 2013), all of which have somewhat unique facial coloration patterns. Yellow-faced bees are a group of minute to moderate-sized, mainly slender bees with sparse, short hairs on the body (Michener 2007). In shape, they resemble wasps, and their lack of pollen-carrying structures gives them a hairless appearance. However, both males and females do possess hairs. On closer inspection, they can be distinguished from wasps by their plumose (branched) hairs, which are unbranched in wasps. *H. anthracinus* is a medium-sized bee with clear to smoky wings, black body, and dark brown to black legs that are unmarked except for a pale area on the tibia of the first pair of legs (Daly & Magnacca 2003).

Males

Males of this species have yellow on the face that is shaped like an oval, which encompasses most of the lower part of the face; yellow on the face does not extend above the base of the antennae (Daly & Magnacca 2003). See Figure 1 for images of males of this species and similar-looking co-occurring species.

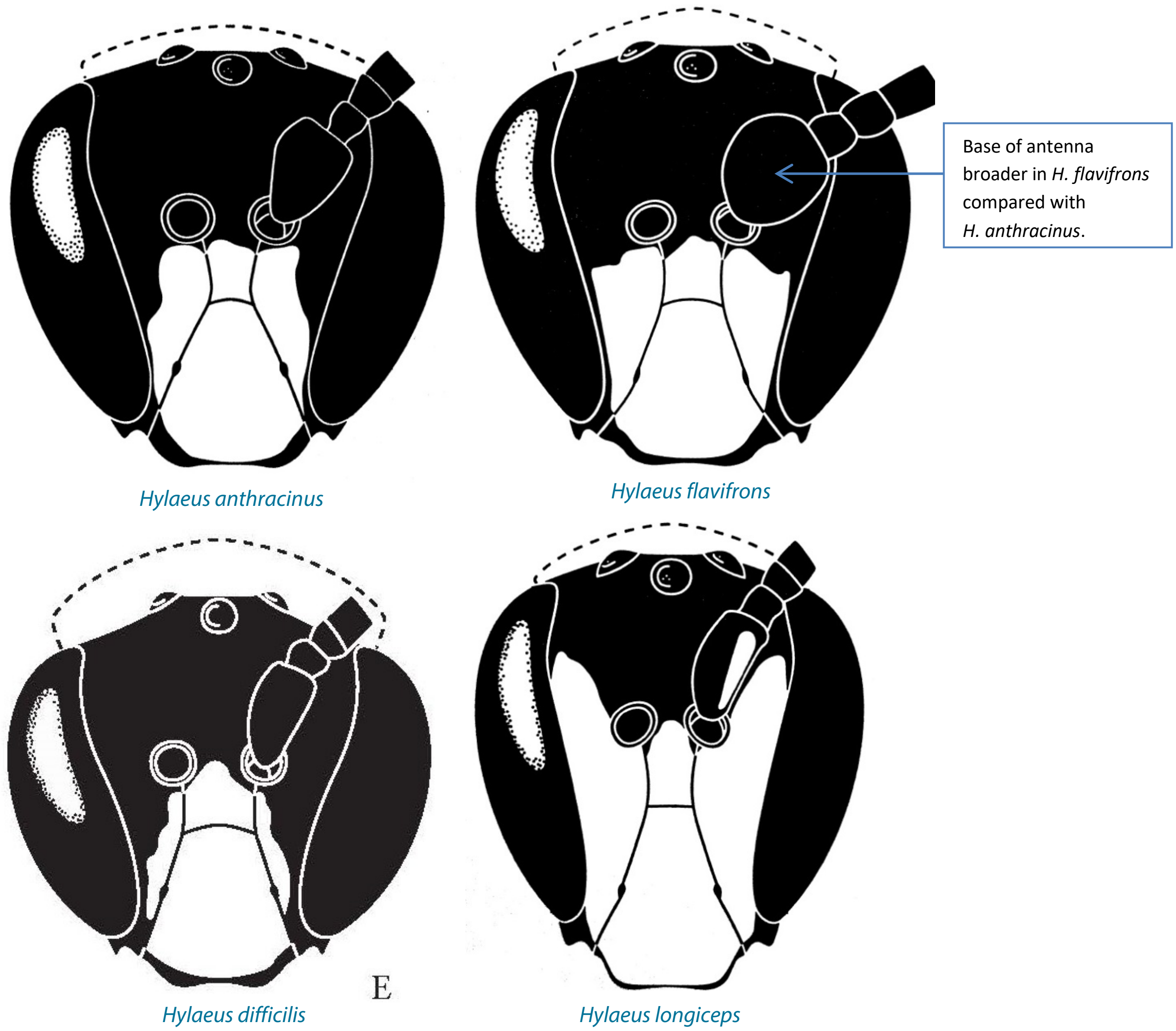
Females

Females of the species are entirely black and lack facial markings. **The female mandible has three small but usually distinct teeth, a feature only shared with the closely related *H. flavifrons*** (Daly & Magnacca 2003).

This species often occurs at known sites with two other yellow-faced bees: *H. flavipes* and *H. longiceps*. Females of *H. anthracinus* are difficult to tell apart from other female *Hylaeus*, but on close examination can be **distinguished from the two co-occurring, similar-looking species by the presence of erect black hairs at the end of the abdomen (the apex), and mandible, which possesses three teeth, rather than**

two large teeth—a unique feature that is only shared with the closely related *H. flavifrons* on Kauai (Daly & Magnacca 2003). **Males may be distinguished from the similar *H. flavifrons* by having a less dilated (expanded) scape (the segment at the base of the antenna), and facial markings that are usually smaller in size** (Daly & Magnacca 2003). See Figure 1 for images of this species and how to distinguish it from look-a-like species.

FIGURE 1: IMAGES OF HYLAEUS ANTHRACINUS (F. SMITH, 1853) & LOOK-A-LIKES



Hylaeus anthracinus (top left) male face with left scape (the segment at the base of the antenna), showing the extent of markings below the base of the antenna. *H. flavifrons* (top right) male face with similar face markings—**despite similar facial markings, a diagnostic feature that can help distinguish these two bees is the broader scape (first segment of the antenna) in *H. flavifrons* compared to *H. anthracinus***. Bottom images are of co-occurring species, *H. difficilis* (bottom left) and *H. longiceps* (bottom right). Used with permission from Daly & Magnacca (2003).

Photos of male *Hylaeus anthracinus* from Keoneoio, Maui. The yellow face markings, which are oval shaped in *H. anthracinus*, do not extend beyond the base of the antennae. NOTE: an unusual white pigment can be seen on the right side of the face in this individual (this area of the face is normally black). Used with permission from Lahaina Photography.

Photo of male *Hylaeus anthracinus* on left and female on the right. Note the female is working to dehydrate a droplet of nectar to bring back to her nest. Used with permission from Karl Magnacca.

Immature Stages

The eggs, larvae, and pupae of *H. anthracinus* have not been described. However, eggs of bees in the *Hylaeus* genus are ovoid in shape, and a pale white color. *Hylaeus* larvae look like white to opaque, small legless caterpillars often with dark eyes. As pupae, they begin to look like adults as a darker appearance and legs begin to develop.

RANGE, DISTRIBUTION, AND ABUNDANCE

Range

Most historic records of this species are from collections made by Perkins from 1892 to 1906 (Daly & Magnacca 2003; Evenhuis 2007). *H. anthracinus* is historically known from coastal habitats and dry forests up to 2000 feet (610 m) elevation on the islands of Oahu, Molokai, Maui, Hawaii, and Lanai (Kahoolawe & Niihau were not searched by Perkins). Recent collections of the bee are primarily from K. Magnacca between 1999 and 2012. It is now thought be restricted to one or a few localities on Oahu, Molokai, Kahoolawe, Maui, and Hawaii. *H anthracinus* has not been found recently on Lanai, which has limited coastal habitat, and may be extirpated from the island (Magnacca 2007a).

CURRENT DISTRIBUTION

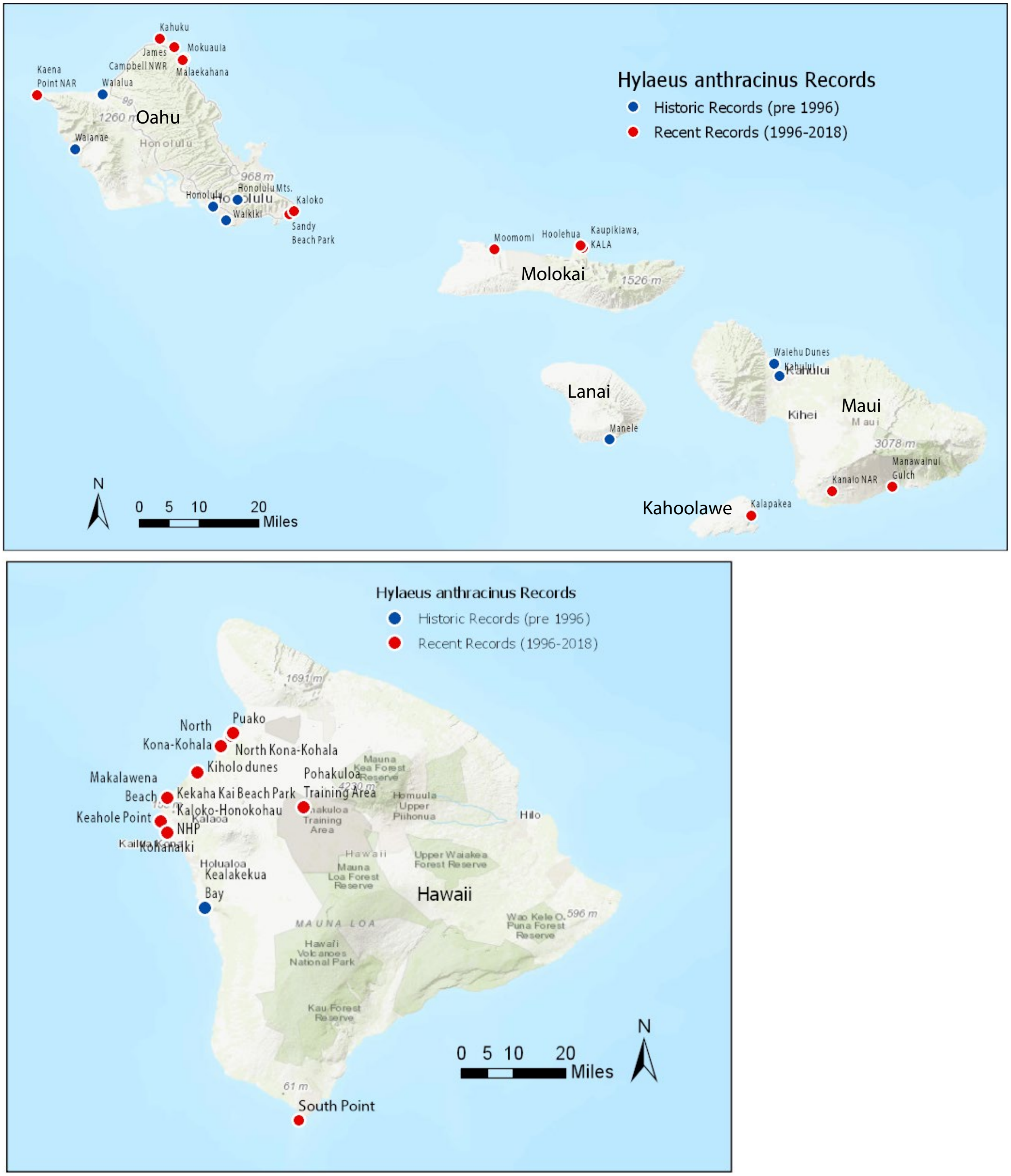
Hylaeus anthracinus is currently known from several small patches of dry coastal habitat on Oahu, Molokai, Kahoolawe, Maui, and Hawaii, and montane dry forest on Maui and Hawaii; six locations occur on the island of Hawaii; one location on Kahoolawe; two locations on Maui; three locations on Molokai; and six locations on Oahu (Daly & Magnacca 2003; Magnacca 2005; Magnacca 2007b; Magnacca & King 2013; iNaturalist 2019). *H. anthracinus* occurs on lands which are under a variety of ownership, including public and private (see Figure 2 for distribution maps, and Table 1 for a list of sites). Many of these locations on all of the islands are small patches of plants, while some on the northwest coast of Hawaii are stretches of coastline several miles long (K. Magnacca pers. Comm., 2021).

Hawaii

On the island of Hawaii, this species occurs along several stretches of coastal habitat from the west and southeast side of the island. Habitat at the coastal sites on Hawaii is characterized by rocky coastline with a mix of native (i.e., naupaka [*Scaevola*]) and nonnative vegetation (i.e., tree heliotrope [*Tournefortia argentea*]), and further inland either landscaped vegetation, nonnative kiawe (*Prosopis pallida*), or bare rock (Magnacca & King 2013). This species occurs in the North Kona-Kohala area, from Puako village to the southern end of the Fairmont Orchid hotel property (Magnacca & King 2013). Other populations are known from Kohanaiki; and Kaulana Bay near Kalae (South Point). *H. anthracinus* was found at Kohanaiki in coastal habitat on tree heliotrope by Magnacca (2007b) and was also found during a 2012 survey of this site (Magnacca & King 2013). At Kaulana Bay, this species appears to be restricted to an area of lava flows east of Kalae, where it and other species of *Hylaeus* were collected in 1999, 2002, 2012, and 2013 (Magnacca 2007a). This site is at the southernmost tip of the island and is thought to be the best coastal habitat for *Hylaeus* species on the island. However, *H. anthracinus* was absent from several sites nearby with potentially suitable vegetation, where other *Hylaeus* species were collected. This species was collected from coastal habitat in the Mahaiula section of Kekaha Kai State Park, Kaloko-Honokohau National Historic Park (NHP), and Makalawena Beach (Aldrich, unpublished data) in 2007; these sites were resurveyed in 2012, though it was not found again (Magnacca & King 2013, K. Magnacca pers. Comm., 2021). This bee has been reintroduced to Puuhonua o Honaunau NHP south of Kealakekua Bay (Magnacca 2020).

One individual was collected in 2004 in montane dry forest in the Pohakuloa Training Area owned by the U.S. Army; however, the presence of additional individuals or confirmation of a breeding population has not been confirmed at this site (Magnacca 2007a).

FIGURE 2: MAP OF KNOWN RECORDS OF *HYLAEUS ANTHRACINUS*



Oahu

In 2012, surveys discovered new populations of *H. anthracinus* on the southeastern and northeastern ends of the island of Oahu (Magnacca & King 2013). A small (but high density) population was found at both Sandy Beach Park and Kaloko (Kaiwi Scenic Shoreline) on the southeastern end of the island. Both sites are in close proximity (approximately 1.2 km [0.75 miles] apart), and have small patches of relatively intact coastal habitat and native coastal vegetation. In the northeast, a smaller, low-density population was found on the shoreline at Malaekahana, which is directly opposite of Mokuauia Islet (Magnacca & King 2013). Another low-density population was discovered at Kahuku Point on northern Oahu near the Turtle Bay Resort. This population inhabits a 1 km (0.6 mi) strip of shoreline near the Turtle Bay Resort golf course. This site is privately owned by the Turtle Bay Resort, and the shoreline habitat has a mix of native and nonnative coastal plants (Magnacca & King 2013). However, subsequent surveys in this area after 2012 did not relocate *H. anthracinus* at Kahuku (K. Magnacca pers. comm., 2018), nor did surveys at Kaena Point on the northwestern tip of the island, despite multiple visits, appropriate weather, and suitable habitat; previously *H. anthracinus* had been observed here as recently as 2002 in stable numbers (Magnacca & King 2013). Other populations may exist offshore of Oahu on the islet of Mokuauia (Goat Island) (Plentovich 2010), however, more recent surveys on the islet have not been conducted for this species. The most recent records of this species are from the Pollinators in Paradise iNaturalist Project—however, because the species is federally listed as endangered, exact locations are obscured and coordinates are not provided (iNaturalist 2019). Several of these records from the project appear to be from the known current localities on Oahu. The exception is a new record from the James Campbell National Wildlife Refuge on Oahu, near Kahuku (Plentovich et al. 2021), where this species has been recorded in the past, but not found in more recent searches by K. Magnacca (pers. comm., 2021).

Kahoolawe

H. anthracinus, although not historically known from the island of Kahoolawe, was observed at one location (Pali o Kalapakea) in 2002. However, the island was not searched broadly (Daly & Magnacca 2003; Magnacca 2007a). Access to the island is limited and no subsequent searches for this species on the island are known.

Maui

H. anthracinus occurs primarily along the coast on Maui, but is also known from one mid elevation site within montane dry forest. Along the coastline, this species has been found at Wailuku sand hills, which had previously supported *H. anthracinus* and several other yellow-faced bees as noted in Perkin's collections from the early 1900's. Now, only small remnant dunes have intact native vegetation potentially suitable for yellow-faced bees, which covers less than 2.5 acres on State lands. The rest of the dunes have been lost due to development or are invaded by the nonnative plant kiawe (*Prosopis pallida*). Unfortunately, the Kahului section of the dunes may no longer contain suitable habitat for yellow-faced bees (Magnacca 2007a). During 1999 and 2001 surveys, *H. anthracinus* was not observed at the Wailuku sand hills (Daly & Magnacca 2003). In 1999, *H. anthracinus* was collected at Manawainui Gulch, a coastal site on land owned by the States Department of Hawaiian Home Lands as well as the Kanaio Natural Area Reserve, in remnant native dry forest in on the southern slopes of Haleakala at 600 m (2,000 ft) elevation (Daly & Magnacca 2003).

Lanai

H. anthracinus was formerly known from Manele on Lanai. No recent records exist for this species on the island, and though no known recent searches have occurred here (last known searches which did not turn up specimens are from 1999; Daly & Magnacca [2003]), it is thought to be extirpated from the island (Magnacca 2007a).

Molokai

On Molokai, *H. anthracinus* has most recently been recorded by K. Magnacca (in 2001) on the coast from The Nature Conservancy's Moomomi Preserve (Daly & Magnacca 2003). Additionally, it was collected from coastal sites on the Kalaupapa Peninsula at Hoolehua Beach and Kaupikiawa on the north end of the island in 2005 (Magnacca 2007b).

TABLE 1: LOCATIONS OF *HYLAEUS ANTHRACINUS* THROUGHOUT THE HAWAIIAN ISLANDS

(see also Figure 2: Map of known records).

Site		Island	Land Owner	Last Year Observed
1	Kohanaiki	Hawaii	Private	2012
2	Kaloko-Honokohau NHP	Hawaii	Federal	2007†
3	Makalawena Beach	Hawaii	Private	2007†
4	Mahaiula Section of Kekaha Kai State Park	Hawaii	State	2007†
5	Kaulana Bay	Hawaii	State (DHHL)	2012
6	Pohakuloa Training Area*	Hawaii	US Army	2004
7	Pali o Kalapakea	Kahoolawe	Federal	2002
8	Kanaio NAR*	Maui	State	1999
9	Manawainui Gulch	Maui	State (DHHL)	1999
10	Moomomi Preserve	Molokai	Private (TNC)	2001
11	Hoolehua Beach	Molokai	Federal (NPS)	2005
12	Kaupikiawa	Molokai	Federal (NPS)	2005
13	Kaena Point NAR	Oahu	State	2002
14	Mokuauia (Goat Island)	Oahu	State	2004
15	Sandy Beach and Kaloko	Oahu	State	2013
16	Malaekahana	Oahu	State	2013
17	Kahuku Point**	Oahu	State	2013
18	James Campbell NWR***	Oahu	Federal	2017

DHHL: Department of Hawaiian Home Lands; TNC: The Nature Conservancy; NPS: National Park Service; NAR: Natural Area Reserve; NHP: National Historical Park; NWR: National Wildlife Refuge. †Exact date and location unknown—Aldrich, unpublished data. *High elevation dry forest site. **Not found here in more recent searches after 2013 (K. Magnacca pers. comm., 2018). ***Observation from iNaturalist; exact location unknown (Date of observation: 5 June 2017).

ABUNDANCE

Current abundance estimates for this species are not known. Despite this species' historic distribution throughout coastal habitats, it now occurs in fewer areas. During Perkins' collections, he called the *Hylaeus* "almost the most ubiquitous of any Hawaiian insects" (Perkins 1913), but more recent surveys show that many species are in decline, including *H. anthracinus* (Daly & Magnacca 2003; Magnacca & King 2013). *Hylaeus anthracinus* is now restricted to small populations in a few narrow corridors of dry coastal and dry forest habitat, some of which is not protected (Daly & Magnacca 2003; Magnacca & King 2013). During 1999–2002, *H. anthracinus* was found abundantly at Kaena on the Oahu coast (Daly & Magnacca 2003), but it has not been found there in more recent searches (Magnacca & King 2013). However, it was found to be in relatively high abundance at coastal sites on the island of Hawaii

(Magnacca & King 2013), but in extremely narrow strips of habitat. *H. anthracinus* also is thought to have a significant population on the island of Kahoolawe (Daly & Magnacca 2003), but no recent searches have occurred here. While more recent searches than 2013 are not published, surveys after this time on Oahu at Kahuku Point indicate this species and other *Hylaeus* have disappeared from this site; however, they have been recorded nearby at a new site within James Campbell National Wildlife Refuge (K. Magnacca pers. comm., 2018).

HABITAT ASSOCIATIONS AND NEEDS

Habitat Associations

Native yellow-faced bees (*Hylaeus* spp.) are a diverse, endemic bee assemblage, and important pollinators and common visitors of native Hawaiian plants (Daly & Magnacca 2003; Magnacca 2007a; Wilson et al. 2010; Koch & Sahli 2013; Miller et al. 2015). Hawaiian yellow-faced bees are found in a wide range of habitats, from low elevation coastal areas to high-elevation forests (Daly & Magnacca 2003). Thus, native *Hylaeus* are known to exploit nearly the entire range of rainfall and elevation on the Islands and in all habitat types; this makes them unique compared to nearly all other native insect groups found across the archipelago (Magnacca 2007a; 2007b). For *H. anthracinus*, it is almost strictly a coastal species, found at several sites along the coastal zone. However, it has also been found in dry forest at higher elevations (up to 610 m [2000 ft] elevation) on the islands of Maui and Hawaii (Magnacca 2007a; 2007b).

Figure 3: Typical *Hylaeus anthracinus* habitat

Typical H. anthracinus habitat on the island of Hawaii, where Coral rubble for nesting is abundant. *Tournefortia argentea* on the right is visited by *Hylaeus* bees. Photo by K. Magnacca, used with permission.

The coastal zone where *H. anthracinus* occurs includes dry coastal strand habitat, which is a distinct habitat zone with salt-adapted coastal plant communities. These communities are shaped by exposure to salt spray and wind, as well as brackish groundwater (Warshauer et al. 2009). Dry coastal communities occur along the coastlines of all the main Hawaiian Islands, extending from sea level up to 300 m (~1000 ft) elevation (Wagner et al. 1999), and are most extensive on the leeward (or more sheltered) sides of the higher islands due to distinct rain shadows (Wagner et al. 1999). These arid coastal communities include flora characterized by low growing, mat forming species closest to the ocean, while further inland other coastal plants grow taller where soil has accumulated (Wagner et al. 1999; Warshauer et al. 2009). It is an area influenced by natural disturbance and marine effects. It is also an area experiencing cumulative human-caused stresses which impact the structure of plant communities. As a result, both native and nonnative plants exist in this ecosystem, and many native species are either at-risk or endangered (Warshauer et al. 2009).

The coastal plant community where this species occurs is made up of shrubs, trees, and herbaceous coastal flora. This habitat mostly consists of a few annual species, including grasses, with the remaining being perennial plants (Warshauer et al. 2009). Coastal strand communities may vary considerably depending on location and with substrate, but in many areas, it consists of common plant communities which occur in this zone across all of the Hawaiian Islands (Warshauer et al. 2009). Most coastal sites where *H. anthracinus* is found have a number of habitat characteristics in common: rocky shoreline with native naupaka and the naturalized tree heliotrope. Additionally, further inland, the vegetation often is composed of either landscaped plants, nonnative kiawe trees (*Prosopis pallida*), or bare rock; consequently, *H. anthracinus* is often found within a narrow (sometimes 10-20 m [32-65 ft] wide) strip of habitat, between these communities and the ocean (Magnacca & King 2013). The dominant and widespread shrub in dry coastal communities is often the native naupaka kahakai (*Scaevola taccada*), which is a main food plant for *H. anthracinus*. Associated vegetation communities, in the narrow corridors of habitat where this species is found may include: akoko (*Euphorbia celastroides* and *E. degeneri*), naio (*Myoporum sandwicense*), ilima (*Sida fallax*), and ohai (*Sesbania tomentosa*) (Wagner et al. 1999; Warshauer et al. 2009). Some of these species can be locally dominant in coastal habitats, and provide a good indication of suitable bee habitat.

While almost strictly coastal, *H. anthracinus* has also been found in dry forest. Limited information is available on the habitat associations at both of the high elevation dry forest sites where this species has been collected on the islands of Maui and Hawaii (exact location of this latter single record is unknown). However, on Hawaii a specimen was collected in a *Kadua coriacea* (kioele, a rare species of plant in the coffee family) fruit capsule. This plant typically occurs in ohia (*Metrosideros*) open canopy forest characterized by weathered substrates and limited groundcover (Wagner et al. 1999), which is generally not ideal habitat for yellow-faced bees (Magnacca & King 2013). On Maui where this species was collected in 1999, remnants of shrubland and montane dry forest communities exist on the southern slopes of Haleakala near 610 m (2000 ft) elevation in the Kanaio Natural Area Reserve. Plant communities in this State Reserve may consist of aalii (*Dodonaea*) shrubland, lama (*Diospyros*) forest and wiliwili or Hawaiian coral tree (*Erythrina*) forest with stands of Oahu hala pepe (*Pleomele*) (Medeiros et al. 1993). *H. anthracinus* is documented visiting *Argemone glauca* in this dry forest community (Daly & Magnacca 2013).

Habitat Needs & Nest Site Selection

Food

This species and other yellow-faced bees are common visitors of a native Hawaiian coastal shrub, naupaka (*Scaevola* spp.) (Daly & Magnacca 2003; Magnacca & King 2013). These plants bloom half-flowers, and are one of the most dominant coastal shrubs. In coastal habitats, *H. anthracinus* seems to favor native strand vegetation, in particular beach naupaka kahakai (*Scaevola taccada*) and ilima (*Sida fallax*), but also commonly forages from the flowers of the nonnative, naturalized tree heliotrope (*Tournefortia argentea*). In these habitats, *H. anthracinus* has also been documented visiting another native naupaka species, naupaka papa (*S. coriacea*—endangered). Other coastal plants visited include naio (*Myoporum sandwicense*), akoko (*Euphorbia celastroides* and *E. degeneri*), ohai (*Sesbania* *tomentosa*—endangered), and caper bush or maiapilo (*Capparis sandwichiana*). At some coastal sites native vegetation may be very limited, and the bees can be restricted to narrow corridors of *Scaevola* and *Tournefortia*, landscaped vegetation, and other nonnative vegetation or bare rock (Magnacca & King 2013; Graham et al. 2015). At one higher elevation site in dry forest, this species was documented foraging on kala (*Argemone glauca*) (Daly & Magnacca 2003). Hawaiian yellow-faced bees may only rarely visit more than one plant while foraging (Miller et al. 2015), and most of time they visit only native flowers (Magnacca 2007a; Wilson et al. 2010; Kuppler et al. 2017). Their high fidelity in forage behavior on a few native species suggests they may provide important pollination services to native Hawaiian plants; as such, healthy populations of this bee could improve the success of native restoration plantings (Miller et al. 2015).

Nest Sites

H. anthracinus nests in hollow twigs in coastal vegetation, so protecting coastal vegetation in large intact patches is very important, to not only provide forage, but also nesting sites. In coastal habitats, they utilize naupaka kahakai (*Scaevola taccada*), an understory shrub, and tree heliotrope (*Tournefortia argentea*; nonnative) for both forage and nesting resources (Graham et al. 2015). They will also nest in coral rubble in full sun and in shaded habitat at coastal sites (Magnacca & King 2013; Graham et al. 2015; see Figure 3); the availability of coral rubble may be a limiting factor in their distribution at some coastal sites on Oahu (Magnacca & King 2013). Artificial nests (or bee blocks) can be employed to support declining native bee populations (Graham et al. 2015). Artificial bee blocks can be designed to attract yellow-faced bees and potentially exclude ants and other crawling pests and predators (Graham et al. 2015; K. Magnacca pers. comm., 2018), thereby helping to sustain native bee populations, which may be potentially important as new habitat is being established.

LIFE HISTORY

Yellow-faced bees (*Hylaeus* spp.) are solitary bees in the Colletidae family, also commonly known as cellophane bees or plasterer bees. Unlike social bees, which live in colonies (the way of life for the well-known honey bee), female yellow-faced bees construct and provision nests on their own, without the help of other bees. Though they are solitary, yellow-faced bees may still nest in aggregations, with nest sites in close proximity to one another.

Nesting

Many solitary bees nest in pre-existing cavities in plant material such as hollow stems and branches, in holes created by wood-boring insects, under bark or rocks, or in burrows in the soil (Michener 2007). Hawaiian yellow-faced bees may nest either above-ground or below ground in pre-existing holes (Daly & Magnacca 2003). Female *H. anthracinus* are known to nest in hollow stems of coastal plants, including native naupaka kahakai (*Scaevola taccada*) and nonnative, naturalized tree heliotrope (*Tournefortia argentea*), as well as pre-existing cavities in coral rubble (Magnacca & King 2013; Graham et al. 2015). This species may also utilize human-made structures, which provide suitable nest cavities, such as coral retaining walls in coastal habitats, and artificial nests with pre-drilled holes (Magnacca & King 2013; Graham et al. 2015; Magnacca pers. comm., 2018).

When searching for a nest site, mated females look for an appropriate-sized nesting cavity in which to make their nest. One of their common names (cellophane bees) refers to the cellophane-like material the bees use to line their nests and make them waterproof (Michener 2007). As solitary bees, each reproductive female will provision her own nest and construct brood cells (chambers where the young bees develop) in a nesting cavity or tunnel. Brood cells are arranged in a linear series from the back of the tunnel to the front.

Nest Structure

Yellow-faced bees, like many other solitary bees, tend to have particular nesting preferences for the size (inside diameter) of the nest tunnel they choose. Nesting studies with *H. anthracinus* indicate they utilize substrate with cavities, around 3.27-3.41 mm in diameter for coral nests and 3.31-3.41 mm in diameter for stem nests (Graham et al. 2015). Graham et al. (2015) found the average outside diameter of selected nests (hollowed branches) to be 13.62 mm. Selected nest cavities are partitioned by female bees into chambers or cells with a cellophane-like substance secreted by special glands (Michener 2007). Cell partitions of some yellow-faced bees, which nest in wood or woody plants, may possess plant fibers shredded from the walls of nest cavities (Daly & Coville 1982). All cell chambers receive a pollen and nectar mixture where the adult female lays one egg. Each nest tunnel may have several cell chambers, with cells measuring approximately 7.78-8.48 mm in length, and tunnels measuring about 57.8 mm in length on average (Graham et al. 2015). The end of each nest tunnel is then sealed by the female with the same cellophane-like substance.

Provisioning for the Young

While many bees have pollen-collecting hairs and pollen transportation structures (e.g., scopa: an external pollen-carrying apparatus on the body), *Hylaeus* species, including *H. anthracinus* have no scopa to carry pollen externally (Michener 2007). Instead, pollen is carried back to nests internally in the crop (a specialized stomach used to store food). Both males and females visit flowers, but only the female provisions for the nest. Females provisioning a nest will collect pollen and nectar from flowering plants to feed the offspring. Related bees are known to groom the pollen from hairs on the body after they visit a plant, to transfer it to the mouth for transport (Michener 2007), and it is possible that *H. anthracinus* employs a similar strategy. Food brought back to the nest to feed the young is stored as a mixture of pollen and nectar in brood cells for larval consumption (Michener 2007). Eggs are laid on the surface of this pollen and nectar mixture in a brood cell and then another cell is created to seal off the egg with its food (Daly & Magnacca 2003). This process is repeated until the cavity is filled with cells, at which point the nest is sealed and the female goes in search of another hole to create a new nest. The eggs develop into larvae that look like legless caterpillars when they hatch. The larvae eat and grow until they are able to pupate. As they develop, yellow-faced bee pupae begin to look like adult bees, and when development is complete, the adult bee emerges and finds a mate to continue the life cycle.

Once mated, female yellow-faced bees may use stored sperm for the rest of their lives, which makes them well-adapted for dispersal in an isolated island chain (Daly & Magnacca 2003). The female lifespan is unknown (though likely less than a year), and while males are often considered short-lived compared to females, an endemic Hawaiian adult male bee (*Hylaeus pubescens*) survived in captivity for 74 days (Daly and Coville 1982).

Active Period

Hylaeus anthracinus is active year round (Daly & Magnacca 2003; Magnacca 2007a; Magnacca & King 2013; Graham et al. 2016; J. Graham unpublished data). Graham et al. (2016) monitored two *H. anthracinus* populations on Oahu and documented bees every month of the year, but found peak activity on flowers between June and July from southern Oahu, and October at a coastal site on the northern end of the island.

THREATS

The primary threats to Hawaiian yellow-faced bees include habitat loss or degradation from agriculture, grazing, and urban development, as well as fire, recreational activities, pesticide use, and invasions by nonnative species. Many coastal Hawaiian ecosystems where this species occurs have been significantly transformed by humans, leaving only remnants of native coastal plant communities in many areas (Liebherr & Polhemus 1997; Cuddihy & Stone 1990; Wagner et al. 1999; Warshauer et al. 2009). Because *H. anthracinus* faces multiple threats and their populations are small, with most restricted to limited coastal strand habitat, the potential for extinction from random events is greatly increased. In fact, dry coastal and dry forest communities where this species occurs have some of the highest proportions of species at risk in Hawaii, including the native plant communities associated with these habitats (Sakai et al. 2002; Warshauer et al. 2009). Details on key threats to *H. anthracinus* follow below.

Grazing—Domestic and Feral Ungulates

If not managed carefully, grazing by feral and domestic ungulates in natural areas or rangelands can significantly alter or degrade native ecosystems. Feral or domestic cattle, sheep, goats, pigs and deer may impose their own selective pressures on native Hawaiian ecosystems. For example, pigs modify habitat and eat seeds of native plants, disrupting natural dispersal and propagation; sheep and goats browse native plants and deplete floral resources; and cattle may trample or alter habitat, creating grasslands where native forests once existed. Their impacts can be seen in both the coastal and forested ecosystems where this species occurs (Wagner et al. 1999; Warshauer et al. 2009; Magnacca & King 2013). Additionally, some yellow-faced bees (including federally endangered *Hylaeus longiceps* which co-occurs with *H. anthracinus*) may nest in or near the ground, so could be impacted directly by ground or soil disturbance caused by the presence of ungulates.

Recreation and Development

The survival of native coastal communities is dependent on the protection of habitat from adverse management actions or recreation uses. Development and recreation use are common pressures to coastal yellow-faced bee habitat. Recreation near the coast may include hiking or off-road vehicle use. Coastal habitat that is frequently used for beach access or off-road vehicles can affect bee habitat by altering the structure of native plant communities, increasing erosion, and by spreading invasive species. More commonly, development can have significant long-lasting impacts by altering or eliminating habitat all together. It is important to encourage visitors to stay on trails and not to remove or import coral rubble in order to avoid moving invasive ants

Pesticides

The use of pesticides may result in direct (i.e., lethal and sublethal) and indirect effects (e.g., injury or harm related to the loss of forage or nesting resources) on bees. Various pathways for exposure exist for bees, including direct exposure, residual exposure through nectar and pollen contamination, or contaminated nesting material. Because exposure routes can vary significantly, potential harm to bees will vary for different species and for different life stages. All native Hawaiian bees are solitary, with a single female that provisions for her nest. Therefore, individual bees lose all of their remaining reproduction potential if they are killed or harmed. In comparison, highly social honey bees have numerous non-reproductive workers, so the loss of a few may not necessarily result in direct harm to the colony.

Some solitary bees are also at risk of exposures to those pesticides that persist in the soil, if they nest directly in the ground. Others that use plant materials to build their nests, including *H. anthracinus* may be exposed to residual pesticides in plant tissues. Additionally, as they develop, larval bees may be impacted by consuming pollen and nectar contaminated with pesticides (Abbott et al. 2008).

Insecticides

Of the various pesticide groups, insecticides pose the most direct risk to pollinators as they target insects (Thompson 2003; Decourtye et al. 2004; Desneux et al. 2007; Zhu et al. 2015; Kopit and Pitts-Singer 2018). Many commonly used insecticides are broad spectrum and thus could kill or otherwise harm a variety of beneficial insects, including adult and immature stages of bees. Systemic insecticides, such as neonicotinoids, have the added concern that they can be expressed in pollen and nectar, making the plants toxic to visiting bees and their young. Furthermore, these chemicals can sometimes be expressed in floral resources months after a treatment (Mach et al. 2017). Neonicotinoids are widely used on agricultural crops that are attractive to pollinators, as well as on horticultural plants and lawns in urban and suburban areas (Cox 2001).

Herbicides

Herbicides are often used to remove unwanted vegetation from roadsides or control invasive weeds. Herbicides generally have low acute toxicity to adult bees (Johnson 2015), but indirect and sublethal effects have been documented (Cousin et al. 2013; Balbuena et al. 2015). More commonly, herbicides are associated with indirect effects on pollinators as they can remove the floral resources that pollinators depend on, effectively reducing the amount of plants they use for foraging and egg laying (Kremen et al. 2002; Tscharntke et al. 2005).

Fungicides

Although often classified as practically non-toxic to bees, research now clearly indicates that some fungicides pose a threat to bees. A number of studies have found subtle yet concerning effects from fungicides on bees. One study found that as fungicide use increased, native bee abundance and richness declined, even when applications occurred outside bloom time (Park et al. 2015). A meta-analysis showed how some fungicide classes significantly contribute to the spread and abundance of honey bee pathogens and parasites (Sanchez Bayo et al. 2016). Also, some fungicides may block bee's natural detoxification route, increasing the toxicity of some insecticides (Pilling et al. 1993; Piling et al. 1995; Schmuck et al. 2003; Iwasa et al. 2004; Biddinger et al. 2013).

Nonnative Ants

Of the invasive species in Hawaii, the most significant threat to yellow-faced bees may be from invasive ants, all of which are introduced to the islands (Magnacca 2007a; Krushelnycky 2019). Of the close to 60 species of introduced ants, most are successful at lower elevations that have experienced habitat degradation (Reimer 1994; Krushelnycky 2019). Invasive ants may predate eggs, larvae, or pupae within nests or compete with adults on plants (Howarth 1985; Magnacca 2007a; Graham et al. 2015). Some ants are attracted to nectar and may consume these floral rewards from plants such as native *Metrosideros polymorpha* (ohia) in higher elevation habitats (Lach 2005). Different species of ants may have more of an impact on yellow-faced bees than others (Lach et al. 2010). Two species, the big-headed ant (*Pheidole megacephala*) and yellow crazy ant (*Anoplolepis gracilipes*) may pose the biggest threat to yellow-faced bees. Furthermore, native *Hylaeus* may be absent from flowers with the big-headed ant, but apparently is unaffected when the Argentine ant (*Linepithema humile*) is present (Lach 2005; 2008). Based on their co-occurrence it is evident that yellow-faced bees can tolerate ants at certain densities. However, it is likely that more long-term research is needed to understand impacts as species become established; especially given that Magnacca & King (2013) found both the yellow crazy ant and the Argentine ant severely reduced or completely eliminated yellow-faced bees at sites (e.g., Pohakuloa Training Area on Hawaii) where yellow-faced bees normally occur in detectable numbers.

Because yellow-faced bees have not evolved with ants, they have developed no strategies to cope with predation and are commonly excluded from habitats where the ants exist. They may also change their nesting behavior to cope with increased densities of ants—in some places (e.g., James Campbell National Wildlife Refuge) *H. anthracinus* may not nest on the ground because of high densities of big-headed ants (*Pheidole megacephala*), which attack nest sites and eat the larvae.

Nonnative Bees

Yellow-faced bees also face competition from exotic pollinators such as the honey bee (*Apis mellifera*) and other nonnative bees, including introduced *Hylaeus* species (*H. albonitens* and *H. strenuus*), small carpenter bees (*Ceratina arizonensis* and *C. smaragdula*), and sweat bees (*Lasioglossum impavidum*); some of which occur abundantly with native yellow-faced bees (Magnacca 2007a; Magnacca & King 2013). Some are also documented to co-occur with *H. anthracinus* at three sites on Oahu (i.e., *H. strenuus*; *C. smaragdula*, *C. dentipes*) (Graham et al. 2015). Although the direct impacts are not known, these species probably compete for floral resources and likely space, as the latter three co-occurring nonnative bees are known to utilize the same plants (*Sceavola taccada* [beach naupaka] and *Tournefortia argentea* [tree heliotrope]) for food and nesting (Graham et al. 2015).

Fire

With coastal strand and dry forest habitat reduced to smaller areas and lacking in habitat continuity, fire has the potential to eliminate or degrade current or newly established habitat, and lead to increased habitat fragmentation. Fire also encourages the establishment of nonnative vegetation, often including species that are fire-adapted (such as non-native grasses), which may perpetuate fire risk and make it difficult for native species to regenerate.

Because yellow faced bees nest in the hollow stems of shrubs in high-quality habitat, fire burning through established, shrubby habitat also will kill yellow-faced bees that are developing inside of these shrubs.

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CONSERVATION PLANNING GUIDE FOR HYLAEUS ANTHRACINUS IN HAWAII

CONSERVATION CONSIDERATIONS AND RECOMMENDATIONS

Hylaeus anthracinus is listed as an endangered species by the U.S. Fish and Wildlife Service. Conservation efforts for *H. anthracinus* may help address known threats to the species, including habitat loss or degradation, nonnative predators, invasive plants, fire, and habitat destruction from ungulates in lowland and higher elevation habitats. One of the main threats known to this species is habitat loss, primarily from the loss of foraging and nesting resources due to habitat destruction and the invasion of nonnative plants. Conserving and restoring populations by planting native forage and nest plants can be an effective conservation strategy to address loss of habitat. Reducing threats that diminish or degrade habitat such as from invasive species, fire, or feral ungulates can also help promote bee populations. In addition, carefully planned land management near populations or identified suitable habitat can help ensure *H. anthracinus* is protected from any potential adverse actions.

Overall, the main conservation and recovery efforts can include planting native floral species and nest plants utilized by *H. anthracinus*, managing new or existing habitat for all its life history needs, and providing connectivity among suitable habitat to promote the long-term persistence of current populations. Furthermore, long-term monitoring of bee habitat and their populations will help determine the effectiveness of management strategies.

In summary, the main actions recommended for conservation of *H. anthracinus* include:

- **Determine *Hylaeus* presence/absence and proximity to known occupied habitat of *H. anthracinus*:**
  - Species description (page 4)
  - Appendix 1: Survey Protocol (page 36)
  - Proximity to known or historic locations (see Range, Distribution and Abundance, page 6) and map (Figure 2, page 7)
- **Habitat Assessment:** Evaluate the current habitat conditions using the Wildlife Habitat Assessment Guide (WHAG) “Yellow Faced Bee” worksheet, and looking for key nectar, pollen, and nest site habitat elements.
- **Habitat Conservation Planning:** Address habitat deficiencies and on-site management risks identified in the WHEG process and consider the following:
  - **Protect and Restore Existing Habitat**: Protect, manage, and restore existing bee habitat, and control threats.
  - **Create Habitat**: Create new and expand existing native floral and nest plants for yellow-faced bees, retain coral rubble at coastal sites for nest material, and – if local experts are available – employ artificial nests with guidance from local experts.
- **Monitoring & Adaptive Management**: Adapt management at habitat sites based on effectiveness of land management actions.

Note: Whether a permanent breeding population exists in dry forests is in question; thus, because populations predominately occur coastally, *H. anthracinus* may benefit more from resources focused on preserving and augmenting coastal populations in coastal strand habitats (Magnacca & King 2013).

DETERMINE HYLAEUS PRESENCE / ABSENCE AND PROXIMITY TO KNOWN OCCUPIED HABITAT

Using species descriptions (starting on page 4, and see Figure 1) and observational survey protocols detailed in Appendix 1 (page 34) of this technical note, determine if yellow faced bees and *H. anthracinus*, specifically, may be present on site.

Using the map in the Biology section (Figure 2, page 7), determine if the site is in relatively close proximity to known or historic populations. Restoring habitat within 1 mile of know *H. anthracinus* habitat will have a greater likelihood of supporting populations of this endangered species.

HABITAT ASSESSMENT

This species has specific habitat requirements, including specific high quality pollen and nectar foraging resources and nesting sites. The Pacific Islands Areas Wildlife Habitat Assessment Guide (WHAG) has a Yellow Faced Bee worksheet, that serves as a tool to help educate conservation planners and landowners, prioritize conservation actions, and quantify habitat or land management improvements for *H. anthracinus* on a single site. The goal is to implement changes through a habitat conservation planning process that will result in improved habitat or protection of existing habitat.

ASSESSMENT OF FLORAL AND NESTING RESOURCES

See the *Hylaeus anthracinus* Biology section (starting on page 3) for information on the current range, habitat needs, and main pollen, nectar and nesting site host plants for this species. To determine if potential habitat already exists for this species at a specific site, use the Yellow Faced Bee WHAG worksheet to assess the following attributes:

- Look for the primary host plants the provide pollen, nectar, and nesting habitat (see Table 2, below) for *H. anthracinus*. The presence of host plants within the known range of this species and the right habitat will provide a good indication of a habitat's potential to support this species.
- Look for other potential nest material, including coral rubble.

TABLE 2: KNOWN *HYLAEUS ANTHRACINUS* POLLEN, NECTAR, AND NEST SITE HOST PLANTS.

Scientific Name	Common Name	Hawaiian Name	Habitat	Habit	Bloom	Nesting (Y/N)†	Water Needs	Status	Distribution*							
									Niihau	Kauai	Oahu	Molokai	Lanai	Maui	Hawaii	Kaho'olawe
Scaevola taccada	Beach naupaka	Naupaka kahakai	Coastal	Shrub	Year-round	Y	Low	Native	X	X	X	X	X	X	X	X
Scaevola coriacea	Creeping naupaka	Naupaka papa	Coastal	Shrub	Year-round; sporadic	N	Low	Native; Endangered	O	O	O	O	O	X	O	
Capparis sandwichiana	Caper bush; Hawaiian caper	Maiapilo	Coastal; dry inland	Shrub	Sporadic: spring; summer	N	Low	Native	X	X	X	X	X	X	X	X

Scientific Name	Common Name	Hawaiian Name	Habitat	Habit	Bloom	Nesting (Y/N)†	Water Needs	Status	Distribution*							
									Niihau	Kauai	Oahu	Molokai	Lanai	Maui	Hawaii	Kaho'olawe
Sida fallax	Ilima	Ilima	Coastal; dry forest; mesic forest	Shrub	Year-round	N	Low	Native	X	X	X	X	X	X	X	X
Myoporum sandwicense	Naio	Naio	Coastal; dry to wet forest	Shrub /tree	Year-round	N	Low	Native	X	X	X	X	X	X	X	
Euphorbia celastroides	Akoko	Akoko	Coastal; dry forest	Shrub	Year-round	N	Low	Native	X	X	X					
Argemone glauca	Prickly poppy	Pua Kala	Sea level to high elevation; dry	Herb	Sporadic	N	Low	Native	X	X	X	X	X	X	X	X
Euphorbia degeneri	Beach akoko	Akoko	Coastal	Shrub	Year-round	N	Low	Native	X	X	X	X		X	X	
Sesbania tomentosa	Ohai	Ohai	Coastal; dry forest	Shrub /tree	Year-round	N	Low	Native; Endangered	O	X	X	X	X	X	X	X
Tournefortia argentea	Tree heliotrope		Coastal	tree		Y	Low	**Nonnative**; Naturalized	X	X	X	X	X	X	X	

*Distribution: X = Current; O = Possibly extirpated. †Plant documented as a nest site; it is possible other plants provide adequate nest material.

HABITAT CONSERVATION PLANNING

The habitat conservation planning process will help land managers and land owners address habitat deficiencies and on-site management risks identified in the habitat assessment process. Habitat conservation planning includes protecting existing habitat and creating new habitat to support *H. anthracinus* populations. Maintaining or creating intact patches of coastal vegetation is very important, to not only provide forage, but also nesting sites. Protection of remaining or newly restored habitat should be a priority.

PROTECT HABITAT

When areas of quality habitat have been identified or created, consider the following management or protective measures.

Habitat Use and Management

Grazing—Domestic and Feral Ungulates

Because native yellow-faced bees are active year-round, the best management strategy is likely to exclude grazing from yellow-faced bee habitat or establish new habitat separate from grazing areas. In general, if ungulates are present at a site, practices to help maintain or establish yellow-faced bee habitat may include:

- Where appropriate, building fences to exclude ungulates, including Axis deer and other feral ungulates, from existing *H. anthracinus* habitat.
- Creating new habitat in areas that are separate and/or protected from feral ungulates or managed grazing practices.

Recreation and Development

Protecting coastal habitat for bees has the added benefit of preserving natural processes, including coastal protection and dune building. Ultimately, fences, barriers and clearly delineated paths can help protect dunes or other sensitive coastal habitat from areas of high recreation use. In general, practices to protect current habitat from recreation and development may include:

- Limiting or eliminating access to restoration areas or sensitive coastal habitat. Access to coastal areas can be limited by building barriers or fences with signage designating the site as a restoration area. Installed signs could also inform the public about sensitive bees and how visitors can contribute to conservation (e.g., by remaining on designated trails, checking shoes and vehicles for invasive hitchhikers, etc.).
- Clearly delineating and marking paths and trails to encourage visitors to avoid damaging surrounding habitat.

Pesticides

Pesticides—including insecticides, fungicides and herbicides—can cause stress on already at-risk *H. anthracinus* populations. Take steps to reduce harm to these vulnerable bees by incorporating cultural, physical and mechanical methods to prevent and manage pests; and mitigating risks to pollinators when pesticides are employed. Ultimately, land owners and land managers must maintain a balance between managing invasive species and pest outbreaks, while still protecting bees and other pollinators from potentially harmful pesticides. In general, if pesticides are used as part of land management, they should be used within a plan that incorporates the following principles and strategies to protect yellow-faced bees and their habitat:

Overarching Pesticide Recommendations

- Create spatial or vegetative buffers between areas of yellow-faced bee habitat and known pesticide application areas. Vegetative buffers should not be attractive to pollinators. Other than targeted use of herbicides to control for invasive plants, the buffers should not receive pesticide applications.
- If pesticides are used in areas adjacent to habitat:
    - Implement techniques to prevent pest populations from growing, including efforts to halt further introduction of non-native animals and plant species.
    - Select the pest management method (chemical, physical or mechanical) that is least harmful to bees.
    - Keep records of pesticide use to help to evaluate the effectiveness of treatments over time.
    - Only use pesticides when pest thresholds have been met or use is otherwise justified.
    - Implement measures to limit off-site movement of pesticides.

- Time pesticide applications to avoid exposure. For example, avoid application of pesticides when flowers are in bloom and/or bees are present.

Insecticide Specific Recommendations

- Avoid the use of nitroguanidine neonicotinoids (clothianidin, dinotefuran, imidicloprid, and thiamethoxam), including the planting of treated seed, in areas adjacent to yellow-faced bee habitat.
- Avoid the establishment of *H. anthracinus* habitat in locations where nitroguanidine neonicotinoid insecticides were applied within the previous two years (including areas planted with treated seeds), as they can persist in the soil and be taken up by plants.
- Avoiding applications within three days of each other, of insecticides and fungicides. For more information on specific combinations that can synergistically increase toxicity to pollinators refer to https://www2.ipm.ucanr.edu/beeprecaution/.

Herbicide Specific Recommendations

- Inventory vegetation in order to identify emerging noxious and invasive weed issues.
- Seek out selective herbicides that are targeted to the plant species that need treating.
- Use targeted application techniques, such as spot treatments, weed wipers or similar methods to protect not-target plants and limit off-site movement.
- Train herbicide applicators in plant identification; reducing accidental damage to non-target plants.
- Apply herbicides at the stage of growth when the weed is most vulnerable and the application most successful. For many weeds, this will be the seedling or rosette stage.
- As possible, make applications to weed plants when desirable plants are dormant.
- Control weeds before bloom or before they set seed to reduce the weed seed bank.
- Reseed or replant if an area is depleted of desirable species after herbicides are used to burn down the areas.

Mowing

While mowing is commonly used to manage vegetation, control invasive weeds, or eliminate encroaching woody plants, if not done carefully it can eliminate or alter the vegetation structure on which *H. anthracinus* and other yellow-faced bee species depend. Many yellow-faced bees predominantly depend on forage and nest material from plants that grow as shrubs or trees; however, these bees also may use herbaceous species for pollen and nectar. Eliminating or mowing dead, shrubby vegetation at any time of year could harm potential or existing nest sites or remove essential floral resources.

In general, strategies to protect current habitat from mowing may include:

- Avoid mowing host plants, or other native floral species that may be used by yellow-faced bees for pollen and nectar (see Table 1 for examples).
- Avoid mowing nest sites.
  - Where possible, maintain patches of shrubs, and dead, pithy vegetation for nesting material.
  - Survey for *Hylaeus* activity and mark existing nest sites (shrubs) where mowing should be avoided.

- Additionally, care should be taken to avoid mowing or eliminating plants as they are becoming established.

Fire

If fire is determined to be a potential threat to current or newly created habitat, include fire breaks or other protective measures in the development of a conservation plan.

CREATE HABITAT

Good *Hylaeus anthracinus* habitat (1) Provides food, in the form of nectar and pollen; (2) Offers shelter and nesting sites; and (3) Is protected from adverse land management actions or other impacts.

Planting Native Vegetation

Diverse habitats that resemble native Hawaiian plant communities will most likely offer the greatest benefits to native yellow-faced bees. Plantings should provide both foraging and nesting resources for all life stages.

NOTE: Careful planning and monitoring is needed if *H. anthracinus* or other sensitive species occur at a selected restoration site. This is a listed species. Therefore, this species needs to be included with a Section 7 evaluation, and consultation with the USFWS likely will be required.

- Choose habitat patches in coastal strand within this species' range and ideally within 1 mile of current known populations to aid in dispersal.
    - Bees may benefit from patches of habitat of any size, though larger areas will provide greater benefits. This species can be found within narrow strips of coastal habitat (sometimes no wider than 10 to 20 m [32 to 65 ft]), between upland communities and the ocean.
    - The flight and foraging range for this species is unknown, though for solitary bees in general it may be 100 meters to 1 kilometer. However, it is suspected Hawaiian yellow-faced bees may have greater dispersal ability because of the presence of individual species on multiple islands (Magnacca & Danforth 2006). Therefore, prioritize sites within about one mile of known habitats.
- Characterize the existing vegetation and site conditions using the Yellow Faced Bee worksheet on the PIA Wildlife Habitat Assessment Guide.
    - Determine the extent to which habitat for this species already exists, and its connectivity or proximity to other habitat.
    - Determine the extent of invasive species.
    - Determine the potential risk from pesticide drift and other potential disturbance.
- Address resource deficiencies identified in WHAG by planting and maintaining flowering plants used by yellow-faced bees. Primary forage plants include naupaka kahakai (*Scaevola taccada*) and ilima (*Sida fallax*), but see Table 1 for more alternatives.
    - Note: Naupaka kahakai, which will also support nesting, is one of the most widely used of all native plants for commercial and residential landscapes in Hawaii, is easy to

propagate from both seeds and cuttings, and can survive prolonged drought (Wagner et al. 1999; Hawaiian Native Plant Propagation Database 2001).
    - Note: Naio (*Myoporum* spp.) shrubs may provide an important pollen resource for brood rearing and in sustaining adults during seasons when other flowers are unavailable (Magnacca & King 2013). However, Naio is currently being attacked by an introduced thrips, and may not thrive.
- ➢ Source plant material locally and select species that are found in natural native coastal communities.
- ➢ For help choosing and sourcing native plant material, cross reference PIA VegSpec with Table 2.
- ➢ Maintain plants used for nesting, in addition to other features of native habitat to provide sheltering and resting sites for adults.
    - Leave woody, hollow, or pithy-stemmed vegetation and ground litter intact, when possible. In particular, establish and/or maintain native *Scaevola* shrubs to support yellow faced bee nesting needs.
    - Debris and dead branches left in place may provide elements which protect and provide nesting material.
    - To augment nesting sites, consider trimming back 10 stem tips on each mature plant that are not yet open to pith.
        - **NOTE**: depending on habitat, native *Scaevola* may have different growth habits and therefore different heights at maturity.
            - Dwarf mature shrubs can be less than 2 feet tall.
            - Small mature shrubs grow from 2-6 feet tall.
            - Medium mature shrubs grow from 6-10 feet tall.
    - Leave coral rubble undisturbed at coastal sites.
        - Because *H. anthracinus* is also known to utilize coral rubble for nesting, leave pieces of coral rubble undisturbed where they naturally occur.
- ➢ Ensure that grazing by feral ungulates does not pose a risk to the new habitat. If this is a risk, fence new areas of habitat in such a way as to keep feral deer and other grazers out of the habitat planting.

Invasive Vegetation Control

Nonnative, invasive plants may outcompete native plants, thereby eliminating otherwise suitable native plant communities that provide habitat for this species. Because they compete for space and resources, controlling invasive plants may turn out to be a first step in restoring or creating native bee habitat.

Note: The dependence of *H. anthracinus* (and co-occurring and federally endangered *H. longiceps*) on the nonnative tree heliotrope (*Tournefortia argentea*) as a floral and nest resource makes control of this species complicated. This plant is widely used by *H. anthracinus* for nesting and foraging at several sites on Oahu and has been documented as the dominant flower visited by this species along the Kona-Kohala coast of Hawaii. It is not considered to be highly invasive, so it is acceptable to leave this plant alone where it occurs, even in areas being developed for new or improved yellow faced bee habitat.

In general, practices to help maintain or establish yellow-faced bee habitat may include:

- ➢ Targeting weed control to help reduce threats of noxious weeds and allow room for restoration plantings.
- ➢ Making site- and plant-specific determinations regarding the need for and level of intervention.
    - Reduction or elimination of invasive plants may be appropriate in some situations to restore a native plant community or maintain an established one that supports *H. anthracinus*.
    - Before removing invasive plants that may provide nectar and pollen for *Hylaeus* bees and other native plant visitors, ensure other floral resources are available that can serve as year-round forage.
        - ▪ Invasive removal may need to be accomplished in phases to ensure the continuous availability of floral resources for adults and for developing young.
    - Avoid or carefully consider the removal of tree heliotrope, since *H. anthracinus* and other co-occurring *Hylaeus* may utilize this plant for both forage and nesting. Additionally, this tree, which has become naturalized, provides a high nectar output for bees (C. King pers. comm., 2018), is culturally significant, and may provide some stabilization in coastal strand habitat that is devoid of other coastal plants.
        - ▪ Because H. anthracinus is federally listed as endangered and may depend on this plant at some sites, it may be advised to consult with the US Fish and Wildlife Service to consider appropriate options given site-specific circumstances.
- ➢ Ensuring that weed management activities do not adversely affect native plant communities, *H. anthracinus*, or other non-target organisms.
- ➢ Preventing the establishment and/or spread of invasive noxious plants.
    - Weeds may need long-term management to keep their populations under control and allow native plants to become established (see more in Adaptive Management).

Artificial Nests

If local experts are available or working on research or regional conservation efforts where they are employing and monitoring artificial nests, consider working with them and hosting artificial nest blocks in restored or new habitat plantings. An overview of the design and use of artificial nests follows below, in order to give planners and partners an understanding of the key elements and challenges of deploying artificial nests in the field.

Creating a Bee Nest Block

Solitary bees like *H. anthracinus*, which naturally nest in above ground hollowed plant stems, may also utilize artificially made nest blocks that mimic their nesting preferences (MacIvor 2017). To provide artificial nest sites for native yellow-faced bees, a bee nest block can be built. A bee nest block is a wooden block with drilled holes which match the nest size (diameter of the hole) that female bees prefer in a nest site. The benefit of providing artificial nesting options is the ability to protect the nest from crawling predators, including one of the biggest threats to yellow-faced bees, invasive ants.

Note: Because ant predation and invasion of nests by parasitoids are such significant threats to yellow-faced bee nests, and research on the effectiveness of exclusion strategies, nest designs and management are still being determined (C. King pers. comm., 2018; K. Magnacca pers. comm., 2018; P.

Krushelnycky pers. comm., 2018), deploying block nests for bees by private landowners may not be encouraged until their effectiveness and sanitation management can be determined in the near future (P. Krushelnycky pers. comm., 2018). **Additionally, because this species is federally listed as endangered, a Biological Opinion should be considered before deploying artificial nest material. Collaborate with local experts who are coordinating with the US Fish and Wildlife Service if you are interested in implementing artificial nest blocks.**

General guidance on creating a bee block for *H. anthracinus* includes elements of the following list detailed below; adapted from Graham et al. (2015; 2016) and K. Magnacca pers. comm. (2018):

1. A block of untreated wood. An 8-inch section of a 2x4 may accommodate several holes.
2. Pre-drilled holes in the widest (deepest) part of the block. Holes may be approximately 3.31-3.41 mm in diameter, and about 51-76 mm (2-3 inches) deep—leaving an area in the back that is undrilled.
3. Several drilled holes about 1.5 inches apart.
4. A durable rope or cord to attach to the block and hang it from a sturdy tree or other suitable hanging structure.
    a. Alternatively, attach a nest block to a post and anchor the post in the ground.
5. Application of Tanglefoot® insect barrier to the rope or post. Tanglefoot® is a very sticky material which is designed to protect trees or other materials from crawling insects. Additionally, it is designed to be long-lasting. **Application of this sticky material is necessary to protect eggs and developing bees from crawling predators such as invasive ants**.
6. Bee block positioned facing morning sun and near some type of visual landmark.
7. Monitoring the nest block for native yellow-faced bee usage.
    a. Other solitary bees (e.g., nonnative leafcutter bees, sweat bees, and small carpenter bees) may utilize the nest blocks, but yellow-faced bees are unique because they will seal their nests with a cellophane-like material.
    b. Nonnative yellow-faced bees (*Hylaeus strenuus* [native to India—found on Kauai and Oahu], which occur in *H. anthracinus* habitat in addition to *H. leptocephalus* [native to Australia—found on Hawaii, Kauai, Molokai, Oahu], and *H. albonitens* [native to Europe—found on Oahu]) which also seal their nests with cellophane-like material have been introduced to Hawaii.
    c. As activity is observed around a nest, photos of bees uploaded to iNaturalist (https://www.inaturalist.org/projects/pollinators-in-paradise) can help land owners confirm which species are utilizing a nest block.
8. Reapplication of Tanglefoot® to the rope or post as needed to protect nesting bees.

Hollow Tube Bundles

Bundles of hollow tubes also can be set out to provide nest sites for solitary bees, including native yellow-faced bees. To employ, use the same general sizes of diameter and length that are provided above for the bee block.

- Experiment with a variety of materials such as plastic, bamboo, reed, cuttings from tree heliotrope, etc.

- **Because of the threat of predation by invasive ants in Hawaii,** use a box or container with one open side to hold the hollowed tube bundles.
    - Hang the box from a sturdy rope or attach to a post and apply Tanglefoot® to the rope or post.
- Bundle the tubes in the container and face the entrances towards morning sun.
- Used, empty nest tubes can be easily replaced with new ones.

Adaptive Management

Flexible adaptive management is key to maintain long-lasting habitat for wildlife, including for yellow-faced bees. Monitoring sites following management or restoration can determine the effectiveness of actions and allow managers to improve on specific practices.

Monitoring

Establishing baseline information on both habitat and yellow-faced bee populations is important not only to understand the bees themselves at a given site, but will inform how future management practices affect both plants and animals on managed lands. Regular, long-term monitoring after restoration or management will be the most informative since yellow-faced bees may have multiple generations in a year and their populations may naturally fluctuate. The response of yellow-faced bees to habitat restoration or land management practices has received little study (but see Miller et al. 2015), thus more information provided by land owners and managers could greatly improve knowledge and refine practices to benefit native pollinators and other plant visitors.

The following monitoring strategies will help determine the effectiveness of management actions:

Monitoring for Hylaeus anthracinus

- Monitor known pollen and nectar forage plants (see Table 2), as well as potential nesting sites, for bee visitation and verify if *H. anthracinus* is present (see *Hylaeus anthracinus* species description (page 4 and Figure 1), and Appendix 1: Survey Protocol, page 34).
    - Surveys can occur year-round on flowering plants, since this species is active during all months of the year.
- Document the presence of *H. anthracinus* and other *Hylaeus* along with their observed behaviors to help measure of the effectiveness of land management.
    - Document plants visited for pollen and nectar, and nesting habits.
        - If important nectar and pollen flower sources are present (see Table 2), they can be monitored to document species presence.
        - If nest plants are present (see Table 2), they can be searched for nest building activity around hollowed stems.
        - If other nest material is present, like coral rubble, any pre-existing holes can be searched and monitored for yellow-faced bee activity.
- Consider taking photos of yellow faced bees seen at flowers or nesting sites and upload to the iNaturalist Pollinators in Paradise project (https://www.inaturalist.org/projects/pollinators-in-paradise)

Native Plants:

- After restoration, monitor habitat for establishment of native plants.
- Determine effectiveness of establishing forage plants by monitoring plant usage by *H. anthracinus*.

Invasive Plants:

- Monitor habitat for new establishment of invasive plants.
- Determine the effectiveness of invasive species control methods.

Fences and Exclosures:

- Ensure exclosures and fences are effective in excluding ungulates from habitat, or in eliminating other threats, such as recreation use. Address issues as they arise.
    - Secure and maintain fences as needed.

Artificial Nests:

- If you are working with local or regional experts in deploying artificial nests, they should be checked for usage by yellow-faced bees to determine their effectiveness and maintenance needs. Other protocols should be followed as required by local experts.
    - Used nests may need to be checked regularly and replaced with new nest material to avoid disease.
    - Nests must always have protections against predatory ants. Reapply Tanglefoot® to the attachment rope or post as needed. **NOTE**: Tanglefoot® may react differently in different circumstances and habitats. (i.e., in particularly wet or dry climates it may require more frequent re-application).

APPENDIX 1: SURVEY PROTOCOL

SURVEY PROTOCOL FOR HAWAIIAN YELLOW-FACED BEES

Note: Single-species targeted surveys for native bees are likely to be logistically challenging. Many native bees have features that may require specialized equipment (or close examination) and an expert to be properly identified to species (especially females, which are often all black without obvious diagnostic features). Despite this, male yellow-faced bees have somewhat unique facial markings (though these can be variable at different sites); *Hylaeus anthracinus* males have an oval yellow mark on the face that does not extend above the base of the antennae (see Figure 1 for images of this and look-a-like species, and the Species Description section for a description of males and females). Additionally, photos of bees uploaded to iNaturalist or another online platform moderated by bee experts can aid in proper identification and contribute to efforts to better understand yellow-faced bees in Hawaii.

Where

Native yellow-faced bees are known to utilize a diversity of terrestrial habitats on the main Hawaiian Islands. *H. anthracinus* is primarily found within coastal vegetation on the islands of Oahu, Molokai, Kahoolawe, Maui, Hawaii, and historically Lanai (see Range, Distribution, and Abundance section and Appendix 2: Map). Sites to monitor can be selected based primarily on habitat suitability: when surveying new areas, seek out places with adequate food (e.g. diverse floral resources including flowering shrubs and trees) and habitat (e.g. native plants, dead wood) to sustain a population. Surveys for this bee can be done in coastal habitats that have features similar to its known habitat requirements (see Habitat Associations and Needs). *H. anthracinus* may be capable of maintaining populations at small areas of habitat, so monitoring bees even in narrow corridors of coastal habitat may be valuable. Despite having a preference for native floral species, nonnative plants may be searched for this species. Additionally, sites dominated by nonnative vegetation may still support this species in pockets of native habitat.

When

Surveys can occur within the window of this species' documented activity, but may be dependent on the amount of floral resources available. Yellow-faced bees are active all year; *H. anthracinus* has been recorded every month of the year (K. Magnacca Personal Database; J. Graham Personal Database), and therefore may be surveyed for all year. Yellow-faced bees visit flowers during sunny periods; this can make it difficult to find bees on days with rapidly changing weather in Hawaii. Native yellow-faced bees are known to forage primarily at high temperatures and light intensities (Kuppler et al. 2017). More commonly, exotic species, especially honey bees, are also active at low temperatures and low light intensity (for instance, earlier in the morning) (Kuppler et al. 2017).

How to Survey

If possible, surveys should be conducted during the following environmental conditions:

Minimum temperature: Above 60°F (~15°C)

Cloud cover: Partly sunny or better. On cooler days the sun can play a very important role in bee activity.

<u>Wind</u>: Low wind, less than 8 MPH.

<u>Precipitation</u>: No rain and dry vegetation.

<u>Time of day</u>: Between 10AM and 4PM. Success is most likely during the warmest parts of the day. However, especially in more arid conditions, some species are known to be active at very early times of day.

<u>How</u>: Yellow-faced bees can be observed from flowers, around nest sites, or sometimes over the ground. In appropriate habitat, search for bees visiting flowers of its main host plants (main food plants include tree heliotrope [*Tournefortia argentea*], naupaka [*Scaevola taccada*], and ilima [*Sida fallax*])—see the Habitat Associations and Needs section and Table 2 for information on other plants visited by this species. Take photos of bees found on flowers or other substrate to document their presence. Close-up images of bees will help in identification, especially of the facial markings of male yellow-faced bees. Flowers visited or nest sites used, date, time of day, and numbers of bees seen can provide important information on yellow-faced bee life history characteristics at a given site. Observational information on yellow-faced bees can be shared on online citizen science platforms such as iNaturalist. This information over the long-term will indicate the suitability of the site to support native bees.

REFERENCES: SURVEY PROTOCOL ONLY

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