Animal and Plant Health Inspection Service
U.S. DEPARTMENT OF AGRICULTURE

Field Release of *Phymastichus coffea* (Hymenoptera: Eulophidae) for the Biological Control of Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera: Scolytinae), in Hawaii

Final Environmental Assessment, May 2023

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Contents

I. Purpose and Need for the Proposed Action

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Permitting and Compliance Coordination (PCC) is proposing to issue permits for release of the wasp *Phymastichus coffea* LaSalle (Hymenoptera: Eulophidae). This organism would be used by a permit applicant for biological control (biocontrol) of the coffee berry borer (CBB), *Hypothenemus hampei* (Ferrari), (Coleoptera: Curculionidae: Scolytinae), in the State of Hawaii.

APHIS has the authority to regulate biological control organisms under the Plant Protection Act of 2000 (Title IV of Pub. L. 106–224). Applicants who wish to study and release biological control organisms into the United States must receive PPQ Form 526 permits for such activities.

This environmental assessment (EA) was prepared to be consistent with APHIS' National Environmental Policy Act of 1969 (NEPA) implementing procedures (Title 7 of the Code of Federal Regulations (CFR), part 372). It examines the potential effects on the quality of the human environment that may be associated with the release of the parasitoid wasp, *P. coffea,* to control CBB in Hawaii. A parasitoid is an insect whose immature stages (larvae and pupae) live as parasites inside their host, eventually killing their hosts (typically other insects). This EA considers a "no action" alternative and the potential effects of the proposed action. Notice of this EA was made available in the Honolulu Star-Advertiser on February 13, 2023 for a 30-day public comment period. APHIS received one comment on the EA by the close of that comment period. No substantive issues were raised in the comment. A response to the comment is included in appendix C of this document.

The information in this EA is from a petition submitted to APHIS for the proposed field release of *P. coffea* (Follett and Wright, 2021).

The permit applicant's purpose for releasing *P. coffea* is to reduce the severity of damage to the coffee crop from infestations of CBB in Hawaii. The CBB is the most destructive insect pest of coffee globally. Though native to Central Africa, CBB is now found in almost every coffee-producing country in the world. In 2010, it first invaded the island of Hawaii where high quality coffee is the second largest cash crop, valued at more than $55 million during the 2020–2021 season. Coffee berry borer has since invaded coffee on the islands of Oahu, Maui, and Kauai. Coffee crop loss due to CBB is estimated at $7.7 million. CBB has had the effect of making coffee farming more intensive and less profitable: damage causes significant losses in yield and alters the flavor profile of salvageable coffee beans. If left unmanaged, CBB can damage more than 90 percent of the crop.

Control of this pest with insecticides is expensive and has limited success if the CBB has reached into the center of the coffee berries (Vega et al., 2015). Therefore, there is a need to identify and release an effective, host-specific biological control organism against CBB in Hawaii. Furthermore, *P. coffea* has proven to be an effective biological control agent of CBB in other coffee growing regions in the world (Escobar-Ramirez et al., 2019), and is the only parasitoid wasp tested thus far that has been shown to reduce yield loss from CBB damage (Infante et al., 2013). *Phymastichus coffea* has the potential to be an effective biological control agent against CBB in Hawaii.

II. Alternatives

This section will explain the two alternatives available to PCC: no action (no issuance of permits) and issuance of permits for environmental release of *P. coffea* into Hawaii. Although APHIS' alternatives are limited to a decision of whether to issue permits for release of *P. coffea*, we describe other methods currently used to control CBB in Hawaii. Use of these control methods is not an APHIS decision, and their use is likely to continue whether or not PCC issues permits for environmental release of *P. coffea*.

The PCC considered a third alternative but will not analyze it further. Under this third alternative, PCC would issue permits for the field release of *P. coffea.* The permits, however, would contain special provisions or requirements concerning release procedures or mitigating measures, such as limited releases of *P. coffea* in Hawaii. There are no issues raised indicating that special provisions or requirements are necessary.

A. No Action

Under the no action alternative, PCC would not issue permits for the field release of *P. coffea* for the control of CBB — the release of this biological control agent would not occur, and current methods to control CBB in Hawaii will continue at current levels. Use of these methods is likely to continue even if PCC issues permits for release of *P. coffea*. Presently, control of CBB in Hawaii is limited to bioinsecticide and cultural control methods.

1. Bioinsecticide Control

The insecticide *Beauveria bassiana,* formulated as BotaniGard®, is sprayed frequently for CBB control. *Beauveria bassiana* is a naturally-occurring soil fungus that attacks various insect species, causing an insect disease known as white muscardine.

2. Cultural Control

Sanitation is done by remove all remaining coffee berries in the field, including immature out-of-season berries, berries dried on the tree, and fallen berries. Berries should be destroyed by burying in the soil 18 inches deep or by burning (University of Hawaii, 2022). Sanitation reduces the spread of CBB.

B. Issue Permits for Environmental Release of *Phymastichus coffea*

Under this alternative, PCC would issue permits for the field release of *P. coffea* for the control of CBB in Hawaii. These permits would contain no special provisions or requirements concerning release procedures or mitigating measures. *Phymastichus coffea* is specific to CBB.

1. *P. coffea* Taxonomic Information

Insect Taxonomy
Order: Hymenoptera
Family: Eulophidae
Genus: *Phymasticus*
Species: *coffea* LaSalle
Common name: none

Phymastichus coffea was collected in Togo in 1987 and described by LaSalle in 1990. The parasitoid wasp belongs to the family Eulophidae, one of the largest families in the order Hymenoptera (wasps, ants, and bees), with nearly 4,000 described species. The subfamily Tetrastichinae, to which the parasitoid belongs, has 42 genera and is the most widespread of all parasitic groups. The subfamily Tetrastichinae has a very wide host range attacking over 100 families of insects in 10 different orders, as well as mites, spider eggs, and even nematodes (LaSalle, 1994). Voucher specimens of *P. coffea* are deposited at Cenicafé (Manizales, Colombia), at the USDA-Agricultural Research Service (ARS) laboratory in Hilo, Hawaii, and at the University of Hawaii at Manoa.

2. Biology of *P. coffea*

Phymastichus coffea is an endoparasitoid of adult CBB, commonly laying two eggs (a male and a female) per host (López-Vaamonde and Moore, 1998). An endoparasitoid is a parasite that lives inside the host (in this case, CBB) and eventually kills it. Both males and females of *P. coffea* develop in a single CBB host, with the female in the abdomen of the host and the male in the prothorax (close to the head of the host) (Espinoza et al., 2009). However, a single female parasitoid is sometimes found living solitarily in the abdomen of the host. *Phymastichus coffea* develops through four major life stages inside the CBB host—egg, larva (three instars lasting ~21 days), pupa (~9 days), and adult. The complete development (egg to adult) occurs over 30–43 days depending on temperature and condition of the CBB host. The parasitoid emerges by cutting an opening in the CBB host's integument (outer shell) (Feldhege, 1992). Females are approximately one millimeter (mm) long, whereas males are half that size (LaSalle, 1990).

The average lifespan of the adult *P. coffea* is 1–2 days for males and 3–4 days for females (Espinoza et al., 2009). On emergence from the host CBB, female parasitoids can have up to 10 eggs in the ovarioles, but more eggs are formed throughout her lifetime (López-Vaamonde and Moore, 1998). Ovarioles are the tubes that form the insect ovary. Adult female *P. coffea* parasitoids can parasitize CBB adults immediately after emergence (Infante et al., 1994). It has been shown that CBB is attracted to certain chemicals released from coffee fruits (Mendesil et al., 2009); chemicals released during CBB feeding on coffee fruits have been shown to attract *P. coffea* (Cruz-López et al., 2016), and may play an important role in mediating the host specificity of *P. coffea* under field conditions.

Gravid (carrying eggs) *P. coffea* females start to search for their hosts immediately after emerging from the adult female CBB host, and parasitism occurs within the first hours after emergence (Infante et al., 1994). *Phymastichus coffea* commonly lays two eggs (a male and a female) (López-Vaamonde and Moore, 1998) in a CBB adult female at the time she is just beginning to enter the coffee berry, which causes paralysis of CBB and prevents further damage to the coffee berry.

The parasitized CBB usually dies within 4–12 days after parasitism (Infante et al., 1994). A *P. coffea* female can parasitize multiple hosts during its short 3 to 4 day lifespan. High levels of parasitism have been recorded in previous studies under cage and field conditions.

3. Geographic Range of *P. coffea*

To date, *P. coffea* has been released in 12 countries as a classical biological control agent (Bustillo et al., 1998; Damon, 2000; Jaramillo et al., 2005; Vega et al., 2015). *Phymastichus coffea* is native to Africa and present in most coffee producing countries on the continent. According to the CABI Invasive Species Compendium (CABI, 2021), *P. coffea* occurs in Kenya, Togo, and Mexico. Kenya and Togo are presumably within the native range, whereas it may have established in Mexico after release as a biological control agent against CBB.

4. Potential Range of *P. coffea* in Hawaii

Hawaii is characteristically tropical, but has moderate temperatures and humidity due to the influence of north and eastern trade winds. The climate at the elevations where coffee is grown should allow survival of *P. coffea* year-round (Follett and Wright, 2021).

5. Impact of *P. coffea* on CBB in Hawaii

Phymastichus coffea is a potentially effective biological control agent for CBB and could be incorporated into existing Integrated Pest Management programs in Hawaii. To achieve maximum *P. coffea* parasitism in the field, releases should be made at times when CBB adults are active (e.g., when trap catches are high or female CBB are actively boring into fruits) and the coffee crop is at a susceptible stage. Studies suggest *P. coffea* may be susceptible to the insecticide *B. bassiana* used to control CBB, however (Barrera, 2005; Castillo et al., 2009; Ruiz et al., 2011), so releases should be timed to avoid *B. bassiana* applications or used in alternation with *B. bassiana* against CBB. If *P. coffea* is highly effective in controlling CBB, then dependence on *B. beauveria* applications could be reduced dramatically.

III. Affected Environment

A. Coffee Berry Borer

1. Coffee Berry Borer Taxonomic Information

Order: Coleoptera
Family: Curculionidae
Subfamily: Scolytinae
Genus: *Hypothenemus*
Species: *H. hampei*
Common name: coffee berry borer (CBB)
Binomial name: *Hypothenemus hampei* (Ferrari, 1867)

Synonyms
Cryphalus hampei Ferrari, 1867
Stephanoderes hampei Ferrari, 1871
Stephanoderes coffeae Hagedorn, 1910
Xyleborus coffeivorus Van der Weele, 1910
Xyloborus cofeicola Campos Novaes, 1922
Hypothenemus coffeae (Hagedorn)

Within the subfamily Scolytinae, the genus *Hypothenemus* is one of the most species-rich. Species in the genus *Hypothenemus* are common in all tropical and subtropical areas. Most *Hypothenemus* species are very small (less than 2 mm long), poorly described, and difficult to distinguish. Several species are globally distributed, undoubtedly aided by human activities.

2. Biology and Reproductive Potential of Coffee Berry Borer

Coffee berry borer attacks coffee berries when the dry matter content of the endosperm, which increases with age, exceeds 20 percent (Jaramillo et al., 2005). The endosperm is the food store part of the seed which contains starch, protein, and other nutrients to support the developing plant embryo. After finding a suitable berry host, CBB bores into the coffee fruit and digs tunnels where it lays eggs. The CBB offspring develop inside the seeds and feed on the nutrient-rich endosperm tissue (Damon, 2000), reducing both coffee yield and quality. Feeding damage caused by CBB can also cause premature fall of berries younger than 80 days (Decazy, 1990). Coffee berry borer adults boring into the berry may remain in the 'A' position (Jaramillo et al., 2006) with the abdomen partially exposed outside of the berry, potentially for weeks, waiting for the dry matter content to reach 20 percent (Jaramillo et al., 2005).

Females lay batches of two–three eggs beginning three days after penetration into the seed. About 31–119 eggs are laid within a single berry over a period of three weeks. Soon after egg laying begins wing muscles of the female degenerate, preventing the female from colonizing other berries (Ticheler, 1963). Multiple generations may occur in the coffee berry under Hawaii conditions. Waterhouse and Norris (1989), suggested that females may leave the berry when all the seed tissue is consumed or deteriorated in some way, or when her offspring begin to emerge from the berry, in order to continue egg-laying in another berry. After CBB bores into the coffee berry it is protected and difficult to control with insecticides.

Figure 1. *Phymastichus coffea* parasitizing a coffee berry borer in a coffee berry. Photo courtesy of Cenicafé.

B. Areas Affected by Coffee Berry Borer

1. Native and Worldwide Distribution

The CBB is the most destructive insect pest of coffee globally. Though native to Central Africa (likely the Ethiopian Highlands), CBB is now found in almost every coffee-producing country in the world. The CBB was first discovered in 1867 in France in coffee seeds traded from unknown origin (Waterhouse and Norris, 1989), and in Africa it was reported in 1901 from Gabon (Le Pelley, 1968) and in 1903 from Zaire (Murphy and Moore, 1990). The beetle is native to central Africa, but the exact origin of the pest is still not clear (Damon, 2000).

2. Present Distribution in Hawaii

In 2010, CBB first invaded the island of Hawaii where high quality coffee is the third largest cash crop. Coffee berry borer has since invaded coffee on the islands of Oahu and Maui and most recently Kauai. Coffee crop loss due to CBB is estimated at $7.7 million. CBB has had the effect of making coffee farming more intensive and less profitable: damage causes significant losses in yield and alters the flavor profile of salvageable coffee beans. If left unmanaged, CBB can damage to greater than 90 percent of the coffee crop. (Yousuf et al., 2021).

3. Coffee Berry Borer Hosts in Hawaii

The CBB feeds almost exclusively on coffee berries. CBB has been found on several incidental non-crop host plants in Hawaii such as haole koa (*Leucaena leucocephala*), black wattle (*Acacia decurrens*), and red fruit passionflower or love-in-a-mist (*Passiflora foetida*). However, to date researchers have found only a very low incidence of CBB in any of these other plants, and no signs of CBB reproduction in any of them. Wild (uncultivated) coffee plants are a significant reservoir for CBB populations (Messing, 2012).

C. Insects Related to CBB and *Phymastichus coffea* in Hawaii

1. Insects Related to Coffee Berry Borer

Information regarding insects taxonomically related to CBB is included because closely related insect species have the greatest potential for attack by *P. coffea* if it is released in Hawaii.

Coffee berry borer (insect Tribe Cryphalini) is distantly related to native Hawaiian Scolytinae species, which are all within the insect Tribe Xyleborini (Johnson et al., 2018). There are other *Hypothenemus* species in Hawaii; all have been introduced and are not native to Hawaii. While there are reports of CBB feeding on plants other than coffee (e.g., *Leucaena leucocephala*), there is no indication that they could complete their life cycle in those hosts. No native Scolytinae are known to use those plants.

2. Insects Related to *P. coffea*

The eulophid genus *Phymastichus* contains two described species: *P. coffea* and *P. xylebori*. The candidate biological control agent *Phymastichus coffea* is not known to currently occur in Hawaii. *Phymastichus xylebori* was introduced into Hawaii and has been found on the Big Island parasitizing *Xyleborus perforans* (island pinhole borer). *Phymastichus xylebori* has not been found in coffee parasitizing CBB in Hawaii.

IV. Environmental Consequences

A. No Action

1. Impact of Coffee Berry Borer on the Environment

The CBB is the most destructive insect pest of coffee globally, inflicting economic loses of over US$500 million annually. Though native to Central Africa, CBB is now found in almost every coffee-producing country in the world. In 2010, it first invaded the island of Hawaii where high quality coffee is the second largest cash crop, valued at more than $55 million during the 2020–2021 season. Coffee berry borer has since invaded coffee on the islands of Oahu, Maui, and Kauai. Coffee crop loss due to CBB is estimated at $7.7 million. CBB has made coffee farming more intensive and less profitable; damage causes significant losses in yield and alters the flavor of salvageable coffee beans. If left unmanaged, CBB can damage greater than 90 percent of the crop.

2. Impact from the Use of Other Control Methods

The continued use of bioinsecticidal and cultural controls at current levels in Hawaii would result if the “no action” alternative is chosen and may continue even if permits are issued for environmental release of *P. coffea* in Hawaii.

a. Bioinsecticide Control

Among the few available insecticides in Hawaii, *B.bassiana* is compatible with environmental and worker safety concerns (Kawabata et al., 2017; Greco et al., 2018; Hollingsworth et al., 2020). However, the control of CBB with *B. bassiana* is expensive and has limited success if the borer has reached the endosperm of the coffee seeds (Vega et al., 2015).

b. Cultural Control

Frequent harvesting (2–3 weeks intervals) and/or “strip picking” at the end of the season to remove remaining infested berries can be effective at reducing CBB to the next growing season (Aristizábal et al., 2017). However, the high cost and shortage of available field labor are challenges faced by coffee growers in Hawaii employing crop sanitation (Aristizábal, 2018). Also, cultural control is not consistently employed across farms (Hollingsworth et al., 2020).

These impacts from the use of other control methods may have environmental consequences even with the implementation of the biological control alternative, depending on the efficacy of *P. coffea* to reduce CBB infestations in Hawaii.

B. Issue Permits for Environmental Release of *Phymastichus coffea*

1. Impact of *P. coffea* on Non-target Insects

Host specificity of *P. coffea* to CBB has been demonstrated through scientific literature and host range testing. If the candidate biological control agent only attacks one or a few insect species closely related to the target insect, it is considered to be very host specific. Host specificity is an essential trait for a biological control organism proposed for environmental release.

a. Scientific Literature

No reports of parasitism by *P. coffea* on other hosts besides CBB under field conditions exist. However, based on the results of no choice laboratory assays, two papers have reported *P. coffea* as oligophagous (i.e., attacking other non-target scolytine hosts in addition to its primary host, CBB) (Table 1) (López-Vaamonde and Moore, 1998; Castillo et al., 2004a).

Table 1. Previous reports of parasitism of Scolytinae species by *Phymastichus coffea* in no-choice laboratory assays (From: Follett and Wright, 2021).

Scolytinae species	Parasitism (%)	Parasitoid emergence (%)	Reference
Hypothenemus hampei (CBB)	67.3, 64	48, 54	López-Vaamonde and Moore, 1998; Castillo et al., 2004a
Hypothenemus obscurus	83.3	15	López-Vaamonde and Moore, 1998
Hypothenemus seriatus	76.6	12	López-Vaamonde and Moore, 1998
Hypothenemus eruditus	6	4	Castillo et al., 2004a
Hypothenemus crudiae	14	14	Castillo et al., 2004a
Hypothenemus plumeriae	0	0	Castillo et al., 2004a
Araptus sp.	70	18	López-Vaamonde and Moore, 1998
Araptus fossifrons	0	0	Castillo et al., 2004a
Scolytodes borealis	0	0	Castillo et al., 2004a
Tomicus piniperda	0	0	Castillo et al., 2004a
Dendroctonus micans	0	0	López-Vaamonde and Moore, 1998

As shown in Table 1, although the parasitoid attacked other scolytines, it was mainly restricted to species belonging to the same genus as its natural host, *Hypothenemus*. Two *Araptus* species were also tested by López-Vaamonde and Moore (1998), and Castillo et al. (2004a) but only one showed positive parasitism. Castillo et al. (2004a) reported that *P. coffea* did not complete its life cycle in *Araptus*, despite relatively high numbers of parasitism attempts in laboratory exposures, while López-Vaamonde and Moore (1998) reported 70 percent parasitism, and 18 percent emergence of parasitoids, with high parasitoid mortality. No other records of the parasitoid attacking *Araptus* species are available in the literature.

b. Host Specificity Testing

The selection of non-target hosts in Hawaii for host specificity testing was based on relatedness of the test species to the target host (Johnson et al., 2018), potential overlap of CBB and non-target species in the environment of Hawaii, and size. Coleoptera (beetle) species commonly occurring in the coffee landscape and species in culture at USDA-ARS in Hilo, Hawaii were also tested; these were species not closely related to CBB but could provide insights into unexpected host use. There are 21 native and 38 non-native scolytine species in Hawaii (Samuelson, 1981; Nishida, 2002; Cognato and Rubinoff, 2008). Because of the relatively large native scolytine fauna in Hawaii, and their remote or poorly studied habitats, only a subset of these species could be tested for their suitability as hosts to *P. coffea*. Exotic and native scolytine species were collected from coffee and macadamia farms and their surrounding habitats, and extensive searches from native forests from different Hawaiian Islands (Hawaii Island, Oahu, Maui, Molokai, Lanai, and Kauai) (Gillett et al., 2020a).

The host selection and parasitism response of *P. coffea* adult females to 43 different species of Coleoptera were investigated, including 23 Scolytinae (six *Hypothenemus* species and 17 others), and four additional beetles from the Curculionidae family (weevil family) (Yousuf et al., 2021). The list included Hawaiian native species (several Scolytinae in the genus *Xyleborus* and *Nesotocus giffardi*, a curculionid weevil), exotic pest species (e.g., the scolytines *Hypothenemus obscurus* (tropical nut borer) and *Xylosandrus compactus* (black twig borer), and the curculionids *Sitophilus oryzae* (rice weevil) and *Cylas formicarius* (sweetpotato weevil)), and beneficial species (e.g., a weed biocontrol agent *Uroplata girardi* from lantana, several coccinellids (lady beetles), and two flat bark beetle predators of CBB, *Cathartus quadricollis* and *Leptophloeus* sp.) (Tables 2–5).

All beetles used in host specificity tests were collected live and later preserved in 75 percent alcohol or pinned for identification by taxonomists with expertise in the various beetle types. The body size of the collected beetle species ranged from 1.0–7.0 mm long but the majority of species were similar in size to CBB which is 1.5–2.0 mm in length. Beetles were collected using Lindgren funnels or bucket or Broca traps baited with denatured ethanol only or ethanol + methanol + ethylene glycol lures, or collected directly from infested plant material (fruits, pods, stems, bark, and seeds), or reared from infested wood in the laboratory (Gillett et al., 2020b). All non-target testing was conducted at the USDA Forest Service quarantine containment facility at Hawaii Volcanoes National Park, Volcano, Hawaii.

Summary of host specificity results.

The candidate biological control agent *P. coffea* was brought from Colombia into a Hawaii quarantine containment facility for host range testing to determine whether the parasitoid might attack non-target species in addition to the target host CBB and thereby pose a risk to Hawaiian native beetle species. Using no-choice tests, 43 different species of Coleoptera were exposed to *P. coffea*, including 23 scolytines (six natives, 17 non-native species including CBB as seen in Table 2), six beneficial species (Table 3) and 12 other species including one native weevil (*N.*

giffardi) (Table 4). Only five species from the genus *Hypothenemus* were parasitized by *P. coffea*, including the two pest species, the target CBB, and *H. obscurus* (tropical nut borer, a macadamia nut pest), and three other exotic species, *H. seriatus*, *H. birmanus*, and *H. crudiae* (Figure 2). Thus, *P. coffea* appears to be host specific at the genus level and should pose no harm to native or other beneficial species such as other biological control agents if released in Hawaii coffee for biological control of CBB. Nevertheless, no level of host specificity testing can ensure zero risk to non-target organisms when introducing a natural enemy in a new habitat (Louda et al., 2003).

Table 2. Parasitism and parasitoid emergence rates in no-choice non-target host acceptance screening of *Phymastichus coffea* exposed to various Scolytinae in the family Curculionidae (Hawaii native and non-native species) (Follett and Wright, 2021).

Beetle Species	**Insect Status**	**Number of Beetles Exposed to *P. coffea***	**Parasitism (%)**	**Parasitoid Emergence (%)**
Xylosandrus compactus	Exotic/pest	80	0	0
Xylosandrus crassiusculus	Exotic	80	0	0
Xyleborinus saxeseni	Exotic	80	0	0
Xyleborinus andrewesi	Exotic	60	0	0
Xyleborus ferrugineus	Exotic	60	0	0
Euwallacea fornicatus	Exotic	60	0	0
Euwallacea interjectus	Exotic	60	0	0
Hypochryphalus sp.	Exotic	60	0	0
Chryphalus sp.	Exotic	80	0	0
Ptilopodius pacificus	Exotic	80	0	0
Xyleborus molokaiensis	Native	15	0	0
Xyleborus mauiensis	Native	15	0	0
Xyleborus simillimus	Native	18	0	0
Xyleborus hawaiiensis	Native	9	0	0
Xyleborus lanaiensis	Native	19	0	0
Xyleborus obliquus	Native	3	0	0
Xyleborus kauaiensis	Native	35	0	0

Table 3. Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* on beneficial Coleoptera (beetle) species (Follett and Wright, 2021).

Beetle family	**Species**	**Insect status**	**Total beetles exposed**	**Parasitism (%)**	**Parasitoid emergence (%)**
Chrysomelidae	*Uroplata girardi*	Exotic	60	0	0
Coccinellidae	*Scymnodes lividigaster*	Exotic	40	0	0
Coccinellidae	*Rhyzobius forestieri*	Exotic	60	0	0
Coccinellidae	*Halmus chalybeus*	Exotic	40	0	0
Laemophloeidae	*Leptophloeus* sp.	Unknown	60	0	0
Silvanidae	*Cathartus quadricollis*	Exotic	80	0	0

Table 4. Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* on Hawaiian native and introduced coleopteran (beetle) species from families and subfamilies other than Curculionidae: Scolytinae (Follett and Wright, 2021).

Family: Subfamily	Species	Insect status	Total beetles exposed	Parasitism (%)	Parasitoid emergence (%)
Anthribidae	*Araecerus simulans* or *A. levipennis*	Unknown	6	0	0
Anthribidae	*Araecerus* sp. near *varians*	Unknown	15	0	0
Brentidae:Brentinae	*Cylas formicarius*	Exotic/Pest	80	0	0
Chrysomelidae: Bruchinae	*Acanthoscelides macrophthalmus*	Unknown	10	0	0
Curculionidae: Cossoninae	*Phloeophagosoma tenuis*	Unknown	8	0	0
Curculionidae: Cossoninae	*Nesotocus giffardi*	Native	12	0	0
Curculionidae: Curculioninae	*Sigastus* sp.	Exotic/Pest	6	0	0
Curculionidae: Platypodinae	*Crossotarsus externedentatus*	Exotic	60	0	0
Dryophthoridae: Dryophthorinae	*Sitophilus oryzae*	Exotic/Pest	60	0	0
Dryophthoridae: Dryophthorinae	*Sitophilus linearis*	Exotic	40	0	0
Nitidulidae: Carpophilinae	*Carpophilus dimidiatus*	Exotic	10	0	0
Nitidulidae: Carpophilinae	*Carpophilus zeaphilus*	Exotic	60	0	0
Tenebrionidae	*Tribolium castaneum*	Exotic/Pest	21	0	0
Tenebrionidae	*Hypophloeus maehleri*	Exotic	60	0	0

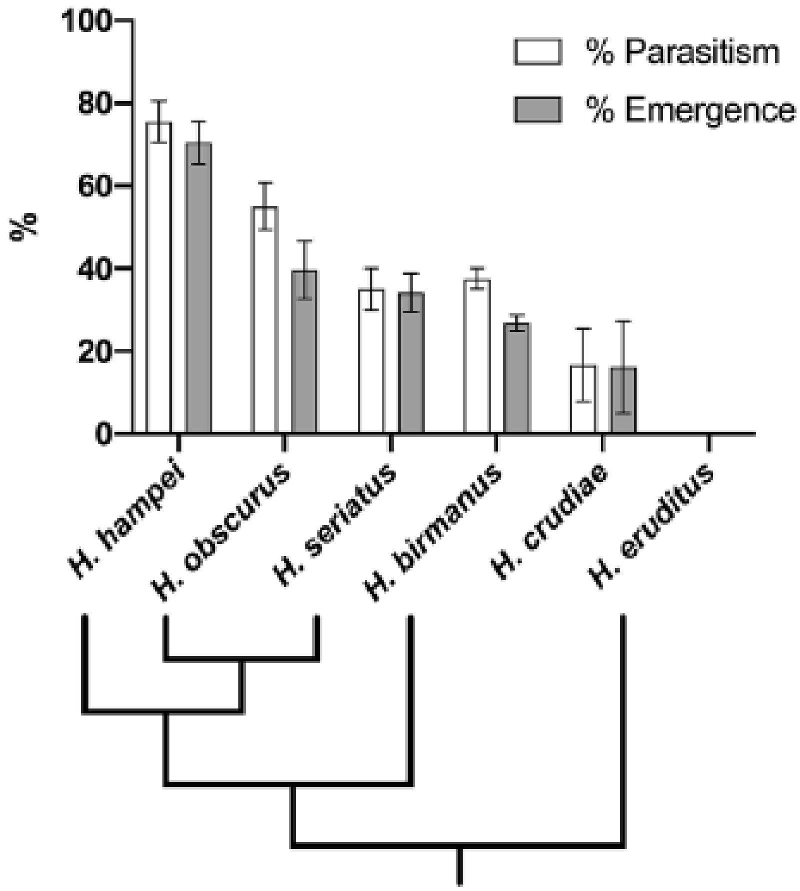

Figure 2. Percentage parasitism and emergence (mean ± SE) of adult *Phymastichus coffea* parasitoids from *Hypothenemus* spp. (Inferred from Johnson et al., (2018)).

See Appendix A for a complete description of host specificity testing and results.

2. Impact of *P. coffea* on Coffee Berry Borer

Phymastichus coffea was chosen as the best candidate parasitoid in Hawaii because of its previously reported high host specificity and ability to significantly reduce and regulate CBB populations in the field (Gutierrez et al., 1998; López-Vaamonde and Moore, 1998; Castillo et al., 2004a,b; Rodríguez et al., 2017). In field cage studies in Mexico and Costa Rico, *P. coffea* proved to be the most promising biological control agent against CBB with parasitism rates as high as 95 percent (Espinoza et al., 2009; Infante et al., 2013). It is expected that *P. coffea* will become established as a biological control agent in Hawaii, providing sustained population suppression of CBB in Hawaii. If establishment of *P. coffea* is variable or unsuccessful in some areas, additional releases will made, or augmentative releases might be considered in some locations.

3. Impact on Human and Animal Health

Phymastichus coffea is a tiny, stingless wasp. Like all parasitic wasps, the immature stages develop as parasitoids of arthropods where, in this case, feeding of the wasp larva inside the CBB host eventually kills the host. This insect poses no risk to humans, livestock, or wildlife.

4. Uncertainties Regarding the Environmental Release of *P. coffea*

Once a biological control agent such as *P. coffea* is released into the environment and becomes established, there is a possibility it could move from the target insect (CBB) to attack nontarget insects. Native species that are closely related to the target species are the most likely to be attacked (Louda et al., 2003). If other insect species were to be attacked by *P. coffea*, the resulting effects could be environmental impacts that may not be easily reversed. Biological control agents such as *P. coffea* generally spread without intervention by man. In principle, therefore, release of this parasitoid at even one site should be considered equivalent to release over the entire area in which potential hosts occur in Hawaii and in which the climate is suitable for reproduction and survival.

In addition, these agents may not be successful in reducing CBB populations in Hawaii. Approximately 12 percent of all parasitoid introductions have led to significant sustained control of the target pests, but the majority of introductions have failed to provide control of the pest (Greathead and Greathead, 1992) either because introduction did not lead to establishment or establishment did not lead to control (Lane et al., 1999).

Actual impacts on CBB populations by *P. coffea* will not be known until after release and establishment occurs. Monitoring will be conducted by the permittee to determine the establishment of *P. coffea* (Appendix B). The environmental consequences discussed under the no action alternative may occur even with the implementation of the action alternative, depending on the efficacy of *P. coffea* to reduce CBB in Hawaii.

5. Cumulative Impacts

“Cumulative impacts are defined as the impacts on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agencies or person undertakes such other actions” (40 CFR 1508.7).

Release of *P. coffea* is not expected to have any negative cumulative impacts in Hawaii because of its host specificity to CBB and the genus *Hypothenemus*. Effective biological control from introduced *P. coffe* may not only provide safe, effective, and long-term control of CBB, but the parasitoid may also result in reduced use of insecticides against CBB.

No other agents have been released in Hawaii for biological control of CBB; therefore, no competitive interactions between agents are expected. Release of *P. coffea* would not affect the ability of growers to continue to control CBB using other methods. Based on host specificity testing, it is also not expected to attack other insects released for biological control of invasive plants or other insect pests, so will not have an adverse effect on other control programs.

Potentially, *P. coffea* might interfere with two resident predators, *Cathartus quadricollis* and *Leptophloeus* sp., that naturally occur in coffee and attack CBB, or vice versa. However, these predators are mainly found in overripe and dried coffee berries naturally predating on the immature stages of CBB in Hawaii (Follett et al., 2016; Brill et al., 2020). Host specificity testing in quarantine showed that *P. coffea* will not parasitize these beetles, and that the beetles did not predate on the parasitoids. Also, these predators attack eggs, larvae and pupae of CBB in overripe and dried berries (left after harvesting), whereas *P. coffea* attacks adult female CBB primarily in developing green berries at an earlier stage of crop maturity. The bioinsecticide *Beauveria bassiana* also has the potential to interfere with *P. coffea* parasitism of CBB and survival. Studies suggest that *P. coffea* may be susceptible to *B. bassiana* (Barrera, 2005; Castillo et al., 2009; Ruiz et al., 2011). Therefore, releases of *P. coffea* should be timed to avoid *B. bassiana* applications or used in alternation with *B. bassiana* against CBB. However, if *P. coffea* is highly effective in controlling CBB, then dependence on *B. bassiana* applications to control CBB could be reduced dramatically.

6. Endangered Species Act

Section 7 of the Endangered Species Act (ESA) and ESA's implementing regulations require Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of federally listed threatened and endangered species or result in the destruction or adverse modification of critical habitat.

APHIS has determined that, based on the host specificity of *P. coffea,* there will be no effect on any listed species or designated critical habitat in Hawaii. In host specificity testing, *P. coffea* is specific only to CBB and the genus *Hypothenemus.* There are no federally listed *Hypothenemus* species in Hawaii, and there are no federally listed species known to depend on or use CBB.

V. Other Issues

A. Equity and Underserved Communities

In Executive Order (EO) 13985, Advancing Racial Equity and Support for Underserved Communities Through the Federal Government, each agency must assess whether, and to what extent, its programs and policies perpetuate systemic barriers to opportunities and benefits for people of color and other underserved groups. In EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, Federal agencies must identify and address disproportionately high and adverse human health or environmental impacts of proposed activities.

Consistent with these EOs, APHIS considered the potential for disproportionately high and adverse human health or environmental effects on any minority populations and low-income populations. APHIS did not identify any disproportionately high or adverse environmental or human health effects from the field release of *P. coffea.* The preferred action will not have disproportionately high or adverse effects to any minority or low-income populations.

Federal agencies also comply with EO 13045, Protection of Children from Environmental Health Risks and Safety Risks. This EO requires each Federal agency, consistent with its mission, to identify and assess environmental health and safety risks that may disproportionately affect children and to ensure its policies, programs, activities, and standards address the potential for disproportionate risks to children. Consistent with EO 13045, APHIS considered the potential for disproportionately high and adverse environmental health and safety risks to children. No aspects of the proposed field release of *P. coffea* could be identified that would have disproportionate effects on children.

B. Cultural Assessment

Synergistic Hawaii Agriculture Council (SHAC) prepared a cultural assessment for the proposed release of *P. coffea* statewide in Hawaii (SHAC, 2021). This assessment is part of the administrative record for this EA and is available upon request. SHAC staff contacted eight community members for cultural assessment interviews via telephone and email. Two declined, while six others agreed to be interviewed in May 2021. Each person contacted fit into one or more of the following categories: 1) Native Hawaiian cultural practitioner, 2) coffee farmer in Hawaii, or 3) conservationist managing lands planted with Hawaiian coffee. To solicit additional feedback from members of the public who fit these criteria, a public notice was published on June 1 in Ka Wai Ola, the Office of Hawaiian Affairs newspaper and on their website at https://kawaiola.news/hoolahalehulehu/public-notice-june-2021/. No responses were received. There are no known traditional Hawaiian cultural practices utilizing the coffee plant, fruit, or seeds, and those interviewed were supportive of the release of *P. coffea* (SHAC, 2021).

C. Climate Change

Climate change will affect Hawaii in many ways as a result of rising air temperatures, changing rainfall patterns, rising sea levels, and increased risk of extreme drought and flooding (Keener et al., 2018).

<u>1) Impact of Climate Change on Proposed Action</u>

The climate of the Kona region of Hawaii is ideal for coffee. Its spring and summer rainfall pattern is favorable for coffee growth (Bittenbender and Smith, 2008). When rainfall coincides with warm temperatures, the conditions are optimum for plant growth and fruit development in coffee, and Kona's cool, dry winter is conducive to maturing the coffee fruits and forming flower buds for the next crop (Bittenbender and Smith, 2008). However, temperatures in the historically cooler and drier mountainous Kona region where coffee is grown have increased over the last few decades. Coffee leaf rust caused by the fungus *Hemileia vastatrix*, is a fungus from Sri Lanka that is affecting coffee production in Hawaii. The disease is exacerbated by climate change because the disease thrives in moist conditions: thus, the disease has now become increasingly common along the Kona coast. For *P. coffea*, the permittee expects that the current climate condition at the elevations where coffee is grown should allow survival of *P. coffea* year-round. However, changing climate could affect the ability of *P. coffea* to establish and control CBB.

<u>2) Impact of Proposed Action on Climate Change</u>
Sources of greenhouse gas emissions as a result of permitting the environmental release of *P. coffea* would include (1) vehicle use by the permittee and cooperators during biocontrol agent delivery and monitoring in the field, and greenhouse gas releases associated with heating and cooling the facilities used for the rearing of *P. coffea*. It is not possible to predict the number of site visits or distance traveled to those sites. Initially, these visits would be expected to be more frequent as *P. coffea* is distributed and monitoring activities are conducted by the permittee and cooperators. Over time, as the agent establishes and spreads on its own, site visits would be expected to decrease. The CBB rearing will be conducted at Cenicafé in Colombia and initial releases of *P. coffea* will be shipped from that location. Production and shipping of *P. coffea* would contribute only a small portion of greenhouse gas, and once established shipments would no longer be necessary. In addition, if *P. coffea* is successful in reducing the invasion of CBB into new locations, the greenhouse gas emissions from vehicles used to apply insecticides or cultural methods to control CBB would be reduced.

VI. Agencies, Organizations, and Individuals Consulted

This EA was prepared and reviewed by personnel from APHIS, ARS, and University of Hawaii at Manoa. The addresses of participating APHIS units and any applicable cooperators are provided below.

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Policy and Program Development
Environmental and Risk Analysis Services
4700 River Road, Unit 149
Riverdale, MD 20737

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine

Pests, Pathogens, and Biocontrol Permits
4700 River Road, Unit 133
Riverdale, MD 20737–1236

U.S. Department of Agriculutre
Agricultural Research Service
U.S. Pacific Basin Agricultural Research Center
64 Nowelo St.
Hilo, Hawaii 96720

Department of Plant and Environmental
Protection Sciences
University of Hawaii at Manoa
3050 Maile Way,
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Appendix A. Host Specificity Testing Methods and Results

(From Yousuf et al., 2021)

Selection of nontarget test arthropods

The selection of non-target hosts in Hawaii was based on phylogenetic relatedness to the target host (Johnson et al., 2018), sympatry of target- and non-target species, and size. Coleoptera species commonly occurring in the coffee landscape and species in culture at USDA-ARS in Hilo, Hawaii were also tested; these were species not phylogenetically close to the target host but could provide insights into unexpected host use. There are 21 native and 38 non-native scolytine species in Hawaii (Samuelson, 1981; Nishida, 2002; Cognato and Rubinoff, 2008). Because of the relatively large native scolytine fauna in Hawaii, and their remote or poorly studied habitats, only a subset of these species could be tested for their suitability as hosts to *P. coffea*. Exotic and native scolytine species were collected from coffee and macadamia farms and their surrounding habitats, and extensive searches from native forests from different Hawaiian Islands (Hawaii Island, Oahu, Maui, Molokai, Lanai and Kauai) (Gillett et al., 2020a).

The researchers investigated the host selection and parasitism response of *P. coffea* adult females to 43 different species of Coleoptera, including 23 Scolytinae (six *Hypothenemus* species and 17 others), and four additional Curculionidae (Yousuf et al., 2021). The list included Hawaiian endemic species (several Scolytinae in the genus *Xyleborus* and *Nesotocus giffardi,* a curculionid weevil), exotic pest species (e.g., the scolytines *Hypothenemus obscurus* [tropical nut borer] and *Xylosandrus compactus* [black twig borer], and the curculionids *Sitophilus oryzae* [rice weevil] and *Cylas formicarius* [sweetpotato weevil]), and beneficial species (e.g. a weed biocontrol agent *Uroplata girardi* from lantana, several coccinellids, and two flat bark beetle predators of *H. hampei*, *Cathartus quadricollis* and *Leptophloeus* sp.) (Yousuf et al., 2021). All beetles used in host specificity tests were collected live and later preserved in 75 percent alcohol or pinned for identification by taxonomists with expertise in the respective taxa. The body size of the collected species ranged from 1.0–7.0 millimeters (mm) but the majority of species were similar in size to *H. hampei* which is 1.5–2.0 mm in length. Beetles were collected using Lindgren funnels or bucket or Broca traps baited with denatured ethanol only or ethanol + methanol + ethylene glycol lures, or collected directly from infested plant material (fruits, pods, stems, bark and seeds), or reared from infested wood in the laboratory (Gillett et al., 2020b). All non-target testing was conducted at the USDA Forest Service quarantine containment facility at Hawaii Volcanoes National Park, Volcano, Hawaii.

Laboratory tests

No-choice tests

The researchers used no-choice tests because these would reflect physiological host range and the most conservative assessment of potential for parasitism in the field, rather than choice tests (Van Driesche and Murray, 2004). Choice tests that include the target host may mask the acceptability of lower ranked hosts, thereby producing false negative results (Withers and Mansfield, 2005).

Twenty individuals of each test species were placed in a sterilized glass Petri dish (80 mm in diameter) lined with filter paper and immediately afterwards four *P. coffea* females (<12 hours old) that had not been exposed to adult hosts prior to the experiments were introduced. Therefore, when ample hosts were available, each replicate consisted of 20 hosts and four parasitoids for a 5:1 host:parasitoid ratio. However, due to difficulties in finding certain species live in adequate numbers, such as native scolytine bark beetles, and difficulties synchronizing parasitoid emergence with field collection or emergence from wood of live beetles, the host:parasitoid ratio and numbers of replicates were adjusted as needed. For example, if only 10 non-target beetles were available for screening, then two replicates each with 5 beetles and 1 parasitoid (maintaining the 5:1 host:parasitoid ratio) were performed. In all non-target host screening tests, *H. hampei* was included as a positive control to confirm parasitoid viability. The host:parasitoid ratio of the *H. hampei* controls was adjusted to match the nontarget species in the test, whether it was 5:1 or otherwise. The generalized behavioral response of the parasitoids towards target and non-target hosts was also determined for a subset of parasitoids by visual observation and video recording of parasitoid behavior (e.g., any contact with the host by landing on the host or antennation, and/or walking on the host). Host acceptance was noted when the parasitoid adopted a characteristic oviposition position on top the elytra of the host (López-Vaamonde and Moore, 1998).

After *P. coffea* exposure, *H. hampei* and all other non-target species were incubated at 25 ± 1°C, 75 ± 10% relative humidity (RH) and 24:0 Light:Dark (L:D) photoperiod for 72 hours. After 72 hours, parasitoids and filter paper linings were removed and the beetles were provided with a small cube (2 x 2 x 2 centimeter (cm)) of general beetle diet. The beetles were again incubated at the same environmental conditions but now at 0:24 (L:D). After 10 days all the remaining diet and frass was removed (without disturbing the parasitized beetles) to avoid fungal contamination. Parasitized beetles typically became paralyzed and eventually died within 4–12 days after parasitoid oviposition. Beetles were held for a total of approximately 5–6 weeks for parasitoid emergence. Beginning after 25 days incubation, *H. hampei* mummies were inspected daily for adult wasp emergence. Parasitism was assessed based on observation of emergence of parasitoid progeny (F1 adult wasps) from the parasitized beetles, by inspection for exit holes on cadavers, or by dissection. Beetles with no exit holes were dissected (by separating the thorax from the abdomen) under a stereomicroscope using fine forceps and entomological pins at 20-100X magnification for evidence of parasitism, i.e., presence of *P. coffea* immature life stages (eggs, larvae or pupae), or unemerged adults. The number of unemerged life stages was recorded for each dissected beetle. After 5–6 weeks of incubation, dead beetle specimens sometimes became very dry and searching for the presence of eggs and early instar larvae was difficult. In such cases, beetles were dissected and examined under a compound microscope at 200X to seek unemerged *P. coffea*. The sex of emerged adult *P. coffea* offspring was determined by examination using a stereomicroscope. In most cases, two parasitoids (one male and one female) emerged per beetle host. To confirm this the sum of the emerged male and female parasitoids in each replicate was divided by two and compared to the number of parasitized hosts with exit holes. The sex of unemerged parasitoids was not determined. For data on parasitism, life stages, sex ratio, and development time, averages were calculated for each replicate (per Petri dish) for each species and used in statistical analysis.

Statistical analysis

Parasitism rate was calculated by dividing the number of parasitized hosts by the total number of hosts exposed to the parasitoids in each replicate. Parasitism included both emerged and unemerged wasps. Emergence rate was calculated by dividing the number of beetles with exit holes by the total number of parasitized hosts (emerged plus unemerged wasps). The sex ratio of the parasitoid progeny was calculated by dividing the number of emerged female parasitoids (F) by the total number of emerged male (M) and female (F) parasitoids [F/ (F+M) x 100]. The Shapiro–Wilk test (Shapiro and Wilk, 1965; Razali and Wah, 2011), numerical approaches (skewness and kurtosis indices), and the normal Q-Q plot-based graphical method were used to check the distribution of the data and showed that the data were not normally distributed. Generalized linear models (GLM) were therefore used to analyze the data, with appropriate distribution function links. Parasitism and emergence rates of the parasitoids, and the percentage of different life stages (larvae, pupae and adults) in parasitized beetles with unemerged parasitoids were analyzed using GLM with a binary logistic function and sex ratio with a gamma log link function. Developmental time of the F1 offspring (egg to adult) was analyzed using GLM with a negative binomial log link function because data were overdispersed (i.e., variance > mean). Wald $\chi 2$ approximations are reported. All analyses were performed using IBM SPSS statistics software.

Results

Out of 43 total coleopteran species tested, including 23 scolytines, *P. coffea* oviposited and completed developed only in the target *Hypothenemus hampei* and four other species of *Hypothenemus*: *H. obscurus*, *H. seriatus, H. birmanus* and *H. crudiae*. Parasitism ($\chi 2 = 65.13$, df = 4, p = 0.0001) and emergence ($\chi 2 = 23.20$, df = 4, p = 0.0001) were significantly higher in *H. hampei* than all other *Hypothenemus* species. *Hypothenemus hampei* had the highest percentage emergence of *P. coffea* at 70.4 percent, whereas *H. crudiae* had the lowest at 16.7 percent. In *H. crudiae*, out of five parasitized hosts only one had emergence. Although *P. coffea* only parasitized *Hypothenemus* spp., it did inspect three other non-target scolytine hosts, *Hypothenemus eruditus*, *Xyleborus kauaiensis* and *Xyleborus ferrugineus,* but left hosts without initiating oviposition (i.e., no parasitism found). Both parasitism and emergence in tests decreased across *Hypothenemus* species with decreasing phylogenetic relatedness to *H. hampei*. *Hypothenemus eruditus*, the most distantly related species tested from *H. hampei* according to Johnson et al. (2018) was not parasitized.

Parasitoid development time among the three different *Hypothenemus* spp. did not differ significantly compared with *H. hampei* ($\chi 2 = 0.17$, df = 4, p = 0.997), but did differ with *H. crudiae*. The mean development time of *P. coffea* from oviposition to adult emergence was shortest in *H. hampei* (32.2 ± 0.5 days, mean ± SE), longest in *H. crudiae* (41.0 ± 0.0 days) and intermediate in the other three *Hypothenemus* spp., which generally agrees with the phylogenetic pattern observed for parasitism and emergence. The percentage of female versus male *P. coffea* emerging from parasitized *H. hampei* was 50.8% ± 0.4 (mean ±SE), which was significantly different ($\chi 2 = 27.3$, df = 4, p = 0.0001) from *H. seriatus* and *H. birmanus*. *Hypothenemus eruditus* was not parasitized by *P. coffea* and hence was not included in any statistical analyses.

Parasitized *H. hampei* had the lowest percentage of unemerged parasitoids compared to the other four *Hypothenemus* species, indicating that *H hampei* is a superior host for *P. coffea* development. For each parasitized host beetle with unemerged parasitoids, invariably two parasitoids were present, and the parasitoids were of the same life stage (larva, pupa, or adult). The frequency of the different life stages for parasitized hosts with unemerged parasitoids differed among *Hypothenemus* species. Parasitized *H. hampei* had a significantly lower percentage of larval ($\chi 2 = 15.10$, df= 3, p= 0.001) and higher percentage of adult parasitoids that were unemerged ($\chi 2 = 18.36$, df= 3, p= 0.0001) compared to the other *Hypothenemus* species. The higher percentage of unemerged parasitoids developing to the adult stage again indicates that *H. hampei* is a superior developmental host than the other *Hypothenemus* spp. The percentage of unemerged pupae found in parasitized *H. hampei* was not significantly different from *H. obscurus*, *H. seriatus* and *H. birmanus*, but *H. crudiae* had a significantly higher percentage of pupae than *H. hampei* ($\chi 2 = 95.40$, df= 4, p= 0.0001). No eggs were found in any of the parasitized *Hypothenemus* hosts.

Summary of laboratory tests in quarantine

The candidate biological control agent *Phymastichus coffea* was brought from Colombia into a Hawaii quarantine containment facility for host range testing to determine whether the parasitoid might attack non-target species in addition to the target host *H. hampei* and thereby pose a risk to Hawaiian endemic species. Using no-choice tests, 43 different species of Coleoptera were exposed to *P. coffea in vitro*, including 23 scolytines (six natives, 17 non-native species including *H. hampei*), six beneficial species and 12 other species including one native weevil (*N. giffardi*). Only five species from the genus *Hypothenemus* were parasitized by *P. coffea,* including the two pest species *H. hampei* (coffee berry borer) and *H. obscurus* (tropical nut borer, a macadamia nut pest), and three other exotic species *H. seriatus*, *H. birmanus*, and *H. crudiae*. Thus, *P. coffea* appears to be host specific at the genus level and should pose no harm to endemic species if released in Hawaii coffee for classical biological control of *H. hampei* (Follett and Wright, 2021).

Note: References included in this section are listed in “VII. References” section of the EA.

Appendix B. Release and post-release monitoring plan for *P. coffea*

Reference specimens

Phymastichus coffea specimens in vials with alcohol have been deposited at multiple locations including Cenicafé, USDA-ARS in Hilo, Hawaii, and the University of Hawaii at Manoa. Hundreds of specimens are available for DNA extraction. All specimens were reared at Cenicafé in Colombia and shipped to Hawaii during host specificity testing in quarantine. A smaller number of pinned specimens is also available.

Planned location and timing of first release

The planned site for the first release is Greenwell Farms (Kealakekua, HI) in Kona, Big Island. The owner is a long-time cooperator with one of the largest coffee farms on the island. Interest is high across the coffee industry and among individual growers to have *P. coffea* releases. The number and timing of releases will be partly dictated by the number of *P. coffea* available.

Post-Release Monitoring

Post-release monitoring will be carried out by the permittee, not by APHIS. APHIS does not oversee or require post-release monitoring.

Biological control agent establishment and spread

Once permits for release of *P. coffea* are obtained, field releases will begin on commercial coffee farms. In selected locations, data will be taken on establishment, dispersal from release points, parasitism rates, coffee berry infestation rates, and crop damage. Non-release sites will be used as controls initially to determine spread. Establishment is not certain and repeated releases may be required. *Phymastichus coffea* could not be found 8–12 months after release in Mexico and it also did not establish in coffee in Colombia after several years of mass releases. In Colombia and Mexico, coffee growers can effectively clean-pick their plantations. This may result in a dearth of hosts for the parasitoids, impacting their ability to establish. In Hawaii, there are widespread feral coffee stands, unmanaged coffee farms, and clear picking is seldom a viable option for various reasons. The year-round presence of hosts is expected to facilitate establishment of *P. coffea*. After release in Hawaii, regular surveys will be conducted to recover *P. coffea* in release areas. Adult CBB will be collected from fruit and returned to the laboratory to determine whether they are parasitized. Diapause has not been investigated previously in *P. coffea* but it has been suggested that diapause may be the survival mechanism for the parasitoids for the period when hosts are rare (McClay, 1993). Overripe and drying coffee berries will be collected from release sites during the off-season and held to determine whether parasitoids emerge over time, possibly from a diapause state.

Biological control agent and target pest densities and distribution over time

Coffee berry borer densities in Hawaii coffee are variable from year to year depending on climactic conditions and control measures (sanitation, *Beauveria bassiana* applications). *Phymastichus coffea* releases will be made on farms where USDA-ARS maintains CBB population monitoring and crop loss assessment activities as part of a long-term area-wide program. Data will be taken on percentage parasitism one week after *P. coffea* release, and adult CBB will be held for parasitoid emergence. Coffee is a seven-month crop from the time of flowering to harvest. *Phymastichus coffea* releases will be made when trapping indicates peak flights of adult CBB and field sampling shows CBB adults boring into coffee berries, the time at which adult CBB are most susceptible to parasitism. Samples will be collected over a range of distances from release sites to assess dispersal of the parasitoids within and among coffee plantations over time. After harvest, samples will be collected from residual fruits on coffee trees and from fallen fruits that lie beneath plants and sustain CBB reservoirs. The abundance of adult CBB available as hosts to *P. coffea* will decline during the months between harvest and the fruit set, a period of four to five months depending on location. The potential for *P. coffea* to enter diapause will be investigated during this period, allowing them to survive within CBB in desiccating fruit on trees or on the ground. Possible diapause will be detected by collecting desiccated fruits form the ground and overripe fruit remaining on trees and holding them to determine if parasitoids emerge over a prolonged period. Laboratory trials will be conducted to assess whether diapause can be induced in *P. coffea* under controlled conditions.

The above studies will measure dispersal of *P. coffea*, as well as their inter-seasonal survival, thus determining whether wide-spread establishment has occurred. Measuring the intergenerational impact of *P. coffea* on CBB populations will occur simultaneously. Cohorts of CBB will be monitored beginning when newly developed coffee fruit become susceptible in the field. Using life table analyses, the contribution of *P. coffea* to CBB generational mortality will be quantified and compared with other mortality factors that may be acting on the CBB population. These analyses will provide an accurate assessment of the impact of the *P. coffea* on CBB densities over time after introduction of the natural enemy.

Impact on selected non-target species for which potential impacts are identified

Preliminary data will be collected on semiochemical attraction of *P. coffea* to different *Hypothenemus* species and other Scolytinae species in vitro to investigate the potential for developing methods to screen parasitoids for non-target effects based on responses to semiochemical diversity. The permittee will compare *P. coffea* responses to chemical signals from Scolyitinae species of varying host-specificity and compare this with two other *Phymastichus* species in Hawaii, *Phymastichus xylebori* LaSalle and *Phymastichus* sp. *nova*. *Phymastichus xylebori* parasitizes *Xyleborus perforans*, while *Phymastichus* sp. nova has been recorded from at least five host beetles. These comparisons will provide insights into the cues used by *Phymastichus* to locate hosts, and potentially the extent to which host specificity is mediated by parasitoid-host chemical interactions.

Various scolytines in the vicinity of release sites will be sampled periodically to determine whether any non-target parasitism occurs. While no non-target host use is predicted in Hawaii, this will serve as a test of the quarantine host-range testing predictions. This information will contribute to the overall understanding of and ability to predict zero impact on nontarget species.

Appendix C. Response to comments

APHIS received one comment on the environmental assessment (EA) for the proposed release of *Phymastichus coffea* by the end of the 30-day comment period. The comment is addressed below.

Comment: My only concern is a caution which you must already be well aware of, and that is, we must have contingencies in place so that releasing wasps to combat coffee borers does not unintentionally destroy other species of insects to the point that our agricultural well-being is worse off than before. The saying, “do not use an axe to swat a fly on your friend’s forehead” is especially relevant here, and so, these wasps should be released only with the understanding that once deployed, we can terminate the wasps once their usefulness has been completed. The federal government should ensure that any release of these wasps be properly monitored, supervised, and controlled to the maximum means as is feasible. And, in light of this proposed operation, robust research and funding needs to occur towards a strategic toolbox of options for future agricultural pest control operations. The precedent set by the outcome of this proposed intervention against coffee borers has national security implications, as well as domestic ones, because of the potential of entomological warfare (“EW”) by both foreign terrorist/stateless actors and countries hostile to the United States, alike. I worry about future crises in which an adversary of the United States wages a “silent” war using insects to destroy our crops or livestock.

Response: This EA described the thorough testing that was conducted to assess the host specificity of *P. coffea.* Thus, it is not expected that *P. coffea* will unintentionally affect other insect species. In addition, as described in appendix B, release of *P. coffea* will be gradual and post-release monitoring will be conducted by the permittees, including any impact on nontarget species.

No biological control agent has ever eradicated its host. Thus, *P. coffea* will not completely eliminate the coffeeberry borer. Rather, both insect species will be reduced to lower levels, as *P. coffea* reduces the population of the coffee berry borer. As the coffee berry borer is reduced, the population of *P. coffea* will follow.

The release of *P. coffea* is not precedent-setting. Biological control agents have been released in Hawaii for many years to target various invasive insect and weed pests. *Phymastichus coffea* will not be used for entomological warfare. The researchers/permittees are well-known to Plant Protection and Quarantine, Permitting and Compliance Coordination, and have a long and well-respected history of work in the field of biological control. Insects are carefully identified and reared to ensure that the correct biological control agent, free of pathogens and parasitoids, is released into the environment.

Comment: While this technology may not be viable now, I would like to ask you to consider this possibility: If future insects could be engineered on-demand with a “fail safe” gene, for example, or cybernetic insects could be developed with precise controls where the U.S. government or state governments could deploy beneficial predatory insects against other invasive or harmful insects for a set period of time, and then, those custom insects extinguish themselves, that would be a beneficial technology for agricultural progress, as well as a useful deterrent against the threat of EW by adversaries of this country.

Response: Engineering of a fail safe gene is beyond the scope of this EA but could be considered for the future.

Decision and Finding of No Significant Impact
for
Field Release of *Phymastichus coffea* (Hymenoptera: Eulophidae) for the Biological Control of Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera: Scolytinae), in Hawaii

May 2023

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) is proposing to issue permits for release of the parasitic wasp *Phymastichus coffea* (Hymenoptera: Eulophidae). *Phymastichus coffea* would be used by the permittee for the classical biological control of the coffee berry borer, *Hypothenemus hampei,* (Coleoptera: Scolytinae), in the State of Hawaii. Before permits are issued for release of *P. coffea*, APHIS must analyze the potential impacts of its release into the State of Hawaii in accordance with USDA, APHIS National Environmental Policy Act implementing regulations (7 Code of Federal Regulations Part 372). APHIS has prepared an environmental assessment (EA) that analyzes the potential environmental consequences of this action. The EA is available from:

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Permitting and Compliance Coordination
4700 River Road, Unit 133
Riverdale, MD 20737
USDA APHIS | Plant Health Environmental Assessments

The EA analyzed the following two alternatives in response to a request for a permit authorizing environmental release of *P. coffea*: (1) no action, and (2) issue permits for the environmental release of *P. coffea* for biological control of the coffee berry borer. A third alternative, to issue permits with special provisions or requirements concerning release procedures or mitigating measures, was considered. However, this alternative was dismissed because no issues were raised that indicated that special provisions or requirements were necessary. The No Action alternative, as described in the EA, would likely result in the continued use at the current level of bioinsecticide and cultural controls for the management of coffee berry borer. These control methods described are not alternatives for decisions to be made by APHIS, but are presently being used to control coffee berry borer in Hawaii and may continue regardless of permit issuance for field release of *P. coffea.* Notice of this EA was made available in the Honolulu Star-Advertiser on February 13, 2023 for a 30-day public comment period. APHIS received one comment on the EA by the close of that comment period. No substantive issues were raised in the comment. A response to the comment is included in appendix C of the EA.

I have decided to authorize APHIS to issue permits for the environmental release of *P. coffea* in the State of Hawaii. The reasons for my decision are:

- *Phymasticus coffea* is sufficiently host specific and poses little, if any, threat to the biological resources, including non-target insect species, of the State of Hawaii.
- *Phymasticus coffea* will have no effect on federally listed threatened and endangered species or their critical habitats in the State of Hawaii.
- *Phymasticus coffea* poses no threat to the health of humans, domestic animals, or wildlife. Although it is a wasp, it does not sting humans or animals.
- No negative cumulative impacts are expected from release of *P. coffea.*
- No adverse cultural impacts are expected from release of *P. coffea.*
- There are no disproportionate adverse effects to underserved communities, minorities, low-income populations, or children in accordance with Executive Order (EO) 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government", EO 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" and EO 13045, "Protection of Children from Environmental Health Risks and Safety Risks."
- While there is not total assurance that the release of *P. coffea* into the environment will be reversible, there is no evidence that this organism will cause any adverse environmental effects.

I have determined that there would be no significant impact to the human environment from the implementation of the action alternative and, therefore, no Environmental Impact Statement needs to be prepared.

/s/ May 3, 2023

David S. Neitch, Acting Director Date
Permitting and Compliance Coordination
U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine