Field Release of the parasitoid *Fopius ceratitivorus* for Biological Control of Mediterranean fruit fly (*Ceratitis capitata*) in Hawaii

Final Environmental Assessment
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I. Proposed Action

A. Summary

The University has submitted an application to the Hawaii Department of Agriculture (HDOA) Plant Quarantine Branch, 1849 Auiki Street, Honolulu, HI 96819 and the Board of Agriculture for a permit to release ***Fopius ceratitivorus*** **(Hymenoptera: Braconidae)** into the environment of the State of Hawai`i under the provisions of Hawaii Revised Statutes, Chapter 141, Department of Agriculture, and Chapter 150A, Plant and Non-Domestic Animal Quarantine. We are seeking to release from quarantine the host specific parasitoid *F. ceratitivorus* for enhanced biological control of the Mediterranean fruit fly, *Ceratitis capitata* (Diptera: Tephritidae) in coffee and other cropping systems throughout Hawai`i.

This Final Environmental Assessment was prepared by the applicant for the Office of Environmental Quality Control (OEQC), Department of Health, State of Hawaii, to comply with the provisions of Hawai`i Revised Statutes, Chapter 343, Environmental Impact Statements.

B. Identification of Applicant

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D. Anticipated Determination

Finding of no significant impact (FONSI)

II. Need for the Proposed Action

A. Detailed description of proposed action

We propose to release adults of the parasitoid *Fopius ceratitivorus* in Hawaii's coffee plantations and other crops to help control the Mediterranean fruit fly.

B. Need for the release

The target pest, the Mediteranean fruit fly, or medfly (*Ceratitis capitata*) is one of the most important agricultural pests in the world, infesting hundreds of species of fruits and vegetables. In Hawaii, it is important both as a direct pest and as a quarantine pest of crops such as citrus, eggplant, guava, loquat, mango, melon, papaya, passion fruit, peach, pepper, persimmon, plum, star fruit, tomato, and zucchini. Current control practices for medfly (promulgated by the USDA-ARS-PBARC Area-Wide Fruit Fly Integrated Pest Management Program) rely on a combination of pesticide-treated bait sprays and field sanitation; as well as the sterile insect technique (SIT); the release of mass-reared extant parasitoids; and semio-chemical based male annihilation. The sustainability of the latter three techniques, once the Federal government stops the influx of implementation funding, is questionable. The use of GF-120 as a bait spray is safer than the previous alternative (malathion); but has nevertheless been shown to be toxic

to a wide array of beneficial (Wang et al. 2005) and non-target insects (Wang & Messing 2006).

Numerous entomologists have emphasized the importance and potential economic benefit of introducing new parasitoids of tephritid fruit flies into Hawaii and other infested regions (Gilstrap & Hart 1987, Messing 1995, Steck et al. 1986, Wharton 1989). Biological control is increasingly viewed as a practical, safe, and economically effective means of fruit fly control, and its importance continues to grow as pesticide use becomes more restricted. Imported parasitoids can incrementally increase fly mortality, reduce infestations, and contribute to a systems approach to quarantine security for fruit and vegetable industry exports (Jang & Moffit 1994).

C. Details of the release

Locations of rearing facilities and release sites
Initial rearing:
Hawaii Dept. of Agriculture Quarantine Facility
1428 S King St., Honolulu, HI 96814-2512

Initial releases to be made at:
Kauai Agricultural Research Center
7370 Kuamoo Rd, Kapaa, HI 96746

Number/Quality to be released
We estimate in the range of several hundred to a thousand adult parasitoids released in coffee orchards.

Timing of release
Autumn-Winter of 2014.

Method of release
Adult parasitoids will be collected in vials in the rearing room, and the vials will be placed under medfly-infested coffee plants for the wasps to emerge.

Common Name and Scientific Classification
Fopius ceratitivorus (Hymenoptera: Braconidae)

Location of Voucher specimens
Voucher specimens are deposited in the Hawaii Department of Agriculture Taxonomy Unit (1428 South King Street, Honolulu, Hawaii 96814-2512); and also at the Texas A & M University Insect Collection, College Station, Texas.

D. Information on the target (host) organism

Classification of target (host) organism
*Ceratitis capitata (*Weidemann): Diptera: Tephritidae
common name = medfly, or Mediterranean fruit fly.

Life history of the target organism
The entire life cycle takes 30–50 days. A female lays 1–10 eggs in a fruit, and may lay as many as 22 eggs per day, and as many as 800 eggs during her lifetime (normally 300–500). Usually females die soon after they cease to oviposit. Under optimum conditions, Medfly can complete its life cycle, which consists of four stages (adult, egg, larvae, and pupae) within 30 days. At lower temperatures, Medfly

requires longer time intervals of up to 100 days to complete its life cycle. The eggs, laid just under the skin of the susceptible fruits, hatch within a few days and the emerging maggots or larvae feed on the fruit pulp. This is the point at which economic damage occurs. The maggots are fully-grown, about one centimeter long, within 7-24 days. When mature, they make their way to the surface of the fruit, drop to the ground, tunnel into the soil and pupate. The adult fly is formed within the pupa and emerges within 8-46 days, forcing its way to the surface of the soil. The newly emerged adults require about 2-3 days to mature before starting to lay eggs.

Pest status of the target organism
The medfly is a major pest of numerous fruits and vegetables in Hawaii, where it attacks avocado, banana, bittermelon, carambola (star fruit), coffee, guava, mango, orange, papaya, peppers, persimmon, and more. Besides being a direct pest causing crop losses, the medfly contributes to increased farm production costs, increased use of toxic insecticides, and quarantine restrictions on horticultural exports. Fruit flies are consistently mentioned in commodity group industry analyses as a major impediment to agricultural growth and diversification

E. Biology of the organism to be released

***Fopius certatitivorus* (Hymenoptera: Braconide) Life History**
Fopius ceratitivorus has a typical opine braconid koinobiont life history. The adult female wasp oviposits into eggs of medfly within fruit tissues, and the wasp larvae develop inside the host larvae, eventually killing the flies in the puparium.

Parasitoid developmental time from egg to adult is 21.8 days (Bokonan-Ganta et al. 2005). Mean longevity of ovipositing females is 16.2 ± 0.5 d; ovarian maturation peaks at 61.6 mature eggs per female on the fifth day after eclosion. Mean number of offspring produced per day by mated females is 5.1 ± 0.4, and realized fecundity is 107.8 ± 12.8 eggs deposited during the female's lifetime (Bokonan-Ganta et al. 2007).

In Guatemalan coffee plantations, field releases of *F. ceratitivorus* resulted in 50-60% reduction of medfly pupae (Pedro Rendon, USDA-APHIS, *personal communication*).

We cannot measure dispersal capability, since the parasitoid is not allowed out of quarantine. Economic and political considerations make long-term studies in the area of origin (central Kenya) unfeasible.

Natural geographic range of *Fopius certatitivorus*
Fopius ceratitivorus is known only from central Kenya, where it was collected in highland coffee plantations near the towns of Ruiru (1°5.72'S, 36°54.22'E at 1609 m elevation) and Rurima (0°38.39'S, 37°29.69'E at 1228 m elevation). Mean annual rainfall in these areas are 1.06 m and 0.9 m, respectively, and the mean temperature ranges are 13-25°C and 15-28°C, respectively (Wharton et al. 2000).

Host range of *Fopius certatitivorus*
Ceratitis capitata is the only known host of *Fopius ceratitivorus*.

Host Range List
Ceratitis capitata

Parasites/hyperparasites
None.

Status as hyperparasite
There are no records of *Fopius ceratitivorus* attacking other parasitoids. No parasitoids in this genus have ever been recorded as hyperparasites.

Locations of rearing facilities and release sites
Initial rearing will take place at the HDOA Insect Quarantine Facility, located at 1428 South King Street, Honolulu, Hawaii. Initial releases will take place at the Kauai Agricultural Research Station, 7370 Kuamoo Rd., Kapaa, HI 96746.

Number/quantity to be released
Releases will continue to be made until the insect becomes established. Precise numbers released per month cannot be predicted at this time, but will be on the order of several hundred.

Timing of release
When Medfly populations are highest in coffee (in late autumn and early winter).

II. Alternatives to the Proposed Action

The actions being considered in this EA are (1) No-Action (i.e., the natural enemy would not be released) or (2) release of *Fopius ceratitivorus*. The no-action alternative will allow the continued levels of crop damage by medfly throughout the state of Hawaii, and the substantial use of insecticides to control this pest. An alternative to the release of the natural enemy would be control through continued spraying of chemical pesticides on host plants of the fly to control the pest. This alternative would be more costly, non-sustainable, and have adverse environmental consequences due to the use of pesticides. The release of *Fopius ceratitivorus* would result in improved biological control of medfly and reduced need for pesticides.

III. Environmental Impacts of the Proposed Action and Alternatives

Expected environmental impacts of the proposed release:
Release of *F. ceratitivorus* will lead to overall reductions of medfly populations statewide, with no other environmental impacts. The no-action alternative will be continuous infestation and use of pesticides in crops throughout Hawaii.

Potential impacts on human environment
There will be no impact of the release of *F. ceratitivorus* on the human environment in Hawaii. This parasitoid does not harm humans, animals, or plants. It will only attack medfly in Hawaii. The no-action alternative will increase probability of adverse pesticide impact on human health.

Literature search for other host records
In the scientific literature, *F. ceratitivorus* has been recorded attacking only medfly.

Host specificity in country of origin
In Kenya, extensive field surveys showed that medfly was the only host of *F. ceratitivorus.* Thorough testing conducted in the HDOA Insect Quarantine Facility showed that *F. ceratitivorus* did not attack any of the non-target Tephritidae which occur in Hawaii.

Interactions with established biocontrol agents
The other extant egg-attacking medfly parasitoid in Hawaii, *F. arisanus*, is an Asian species adapted to hot lowland areas. In Hawaii, *F. arisanus* is largely absent from higher elevation medfly infestations (such as Jerusalem cherry, *Solanum pseudocapsicum*, widely spread near Volcano National Park). *Fopius ceratitivorus* will occupy a different micro-climatic range than *F. arisanus* (Kroder & Messing 2010). Also, experiments in quarantine have shown that multi-parasitism (attack of the same host individual by two different parasitoid species) is quite low between *F. ceratitivorus* and *F. arisanus* (10-16%), even when kept closely together in a small cage. In those few cases where multi-parasitism occurred, *F. ceratitivorus* did not interfere with or reduce the level of parasitism caused by *F. arisanus* (Bokonon-Ganta et al. 2005).

Potential impact on T&E species
There is no potential impact on any threatened or endangered species.

Impact to related non-target potential hosts
There are 33 potential non-target tephritid fly species in Hawaii, including 26 endemic species, and five deliberately introduced and two inadvertently introduced weed biocontrol agents. Among the 26 endemic species, 21 species belong to the genus *Trupanea*, which are predominantly flower-head feeders. The other 5 are stem miners. Not a single native tephritid species feeds on or in fruits.

After years of field surveys and laboratory studies in Hawaii, not a single case has ever been found in which a deliberately introduced parasitoid of tephritid fruit flies has attacked a native Hawaiian species. There have been some cases in which the parasitoids attacked exotic tephritids that were introduced for biocontrol of weeds, but never any indication that this reduced the efficacy of weed control (Duan & Messing 1997a,b; 1998; 1999; 2000a,b; Duan et al. 1997; 1998; 2000; Purcell et al. 1997).

We obtained cohorts of *F. ceratitivorus* from Guatemala, and reared it in the Hawaii Dept. of Agriculture Quarantine Facility in Honolulu for 3 years. During that time we evaluated the biology and host range of this parasitoid, and feel confident of its potential efficacy and environmental safety. In quarantine, we

tested the potential impact of *F. ceratitivorus* against representative non-target flies in Hawaii, including the gall-forming weed-biocontrol agent *Procecidochares alani* and (following recommendations of the Plants and Animals Advisory Committee) the endemic flowerhead-feeding fly *Trupanea dubautiae*, as well as another gall-forming weed biocontrol agent, *Eutreta xanthochaeta*. These were chosen to represent both native and exotic non-target flies, and feeders in both types of plant tissue (flowers and stem galls). We cannot test fruit feeders, as none occur in Hawaii.

Using recognized test protocols, not a single case of successful parasitism of a non-target fly by *F. ceratitivorus* was recorded. The egg-attacking parasitoids do not recognize the non-target flies as suitable hosts – they do not even probe (i.e., try to sting with their ovipositor) into the plant substrate. *F. ceratitivorus* has evolved to sting fly eggs in fruit tissues only. Results of these studies were evaluated and published in peer-reviewed journals (see References).

Potential of *F. ceratitivorus* to act as a hyperparasite

There are no records in the scientific literature of *F. ceratitivorus* acting as a hyperparasite. The development of the parasitoid in the host egg and larva is highly synchronized and very host specific, such that it could not develop as a hyperparasitoid in other insects.

Potential of *F. ceratitivorus* to attack non-targets in the mainland U.S

Medfly is the only known host of *F. ceratitivorus*. Current export inspections and certifications are in place to insure that plant material arriving on the mainland from Hawaii is not infested with medfly or other agricultural pests. Even were the parasitoid to be accidentally transported to the mainland, no physiologically suitable host species occur there, other than medfly.

IV. Environmental Assessment Process and Environmental Permits

A. Basis for Environmental Assessment

This Environmental Assessment was prepared in accordance with Chapter 343, Hawaii Revised Statutes (HRS) by the proposing agency. The EA was triggered because state funding was used by UH in the research conducted. The University of Hawaii is acting as the approving agency in accordance with Chapter 343. A draft environmental assessment (EA) was prepared by the proposing agency and posted in The Environmental Notice of the Office of Environmental Quality Control in December 2008. A single person replied during the 30-day comment period. Answers to questions raised by this person are attached as Appendix 1.

B. Environmental Permits

The proposed action requires permits from United States Department of Agriculture Plant Protection and Quarantine (USDA/APHIS/PPQ) - and the Hawaii Board of Agriculture.

Conditions for the environmental release of *F. ceratitivorus* have been established by the Hawaii Board of Agriculture under the provisions of HRS Chapters 141 (Department of Agriculture) and 150A (Plant and Non-Domestic Animal Quarantine).

Permit conditions for the release of *F. ceratitivorus* into the environment were obtained from USDA/APHIS/PPQ (Permit No. 69250).

V. Listing of Agencies and Persons Consulted

A. Public Meetings

This proposed action, to release *F. ceratitivorus* for control of the medfly, has gone through a public notification process through the Board of Agriculture permitting process. This is in accordance with Chapter 92 (Public Agency Meetings and Records), HRS, commonly referred to as the Sunshine Law. As part of this process the public was notified and had the opportunity to attend, comment and testify on this proposed release at the Plants and Animals Committee meeting and at a Board of Agriculture meeting. No comments opposed to this action were presented at these public meetings.

B. List of Consulted Parties

Following is a list parties, agencies, and individuals that were consulted:

Hawaii Board of Agriculture
Hawaii Department of Business, Economic Development & Tourism, Small Business Regulatory Review Board
Dr. John Sivinski, USDA Agricultural Research Service
Dr. Robert Wharton, Texas A & M University
Mr. Kenneth Teramoto, Hawaii Dept. of Agriculture

HDOA Entomology Advisory Sub-Committees
- Dr. Lorna Arita-Tsutsumi, entomologist, University of Hawaii, Hilo
- Dr. Peter Follet, entomologist, USDA Agricultural Research Service
- Dr. Frank Howarth, entomologist, Bishop Museum
- Dr. Arnold Hara, entomologist, University of Hawaii, Manoa
- Dr. Ronald Mau, entomologist, University of Hawaii, Manoa
- Dr. Mark Wright, entomologist, University of Hawaii, Manoa
- Dr. Daniel Rubinoff, entomologist, University of Hawaii, Manoa
- Dr. Robert Curtiss, Hawaii Dept. of Agriculture

HDOA Plants and Animals Advisory Committees
- Dr. Roy Nishimoto, University of Hawaii, Manoa
- Dr. Mindy Wilkinson, Hawaii Department of Land and Natural Resources
- Mr. Lyle Wong, Hawaii Department of Agriculture
- Dr. Chris Kelly, University of Hawaii at Manoa
- Dr. Sarah Park, Hawaii Department of Health
- Dr. Genevieve Salmonson, Office of Environmental Quality Control, Dept. of Health
- Dr. Melissa Viray, Hawaii Department of Health
- Dr. Robert Hauff, Hawaii DLNR
- Dr. Neil Reimer, Hawaii Dept. of Agriculture
- Mr. John McHugh, Hawaii Farm Bureau
- Mr. Ken Redmond, former Director, Honolulu Zoo

VI. Findings and Reasons

Chapter 11-200-12, HRS, outlines those factors agencies must consider when determining whether and action has potential for a significant effect.

1) involves an irrevocable commitment to loss or destruction of any natural or cultural resources.
Medfly is detrimental to natural and cultural resources such as native plants. Control of medfly will be beneficial to natural and cultural resources.

2) Curtails the range of beneficial uses of the environment.
The proposed action will not curtail beneficial uses of the environment. In fact, it will cause a decline in the population of medfly, which currently infests many fruits, both cultivated and in the wild. A decline in medfly densities will allow Hawaii residents to enjoy fruit with less likelihood of maggot infestation.

3) Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders.
The proposed action does not conflict with the state's environmental policies or goals and guidelines as expressed in Chapter 344, HRS. The proposed action is in harmony with these guidelines as it will mitigate damage from this invasive insect.

4) Substantially affects the economic or social welfare of the community or state.
The proposed action will not negatively affect the economic or social welfare of the state. Control of medfly by the natural enemy will result in an economic and social benefit for fruit and vegetable farmers and home gardeners as they will be able to decrease their use of pesticides to control medfly.

5) Substantially affects public health
The proposed action will have a positive benefit on public health. Decreases in the medfly population will result in a decrease in pesticide spraying for this pest.

6) Involves substantial secondary impacts, such as population changes or effects on public facilities.
No secondary impacts on population changes or public facilities are expected from the control of this insect.

7) Involves a substantial degradation of environmental quality.
No substantial degradation of environmental quality is expected from the release of this natural enemy. In fact, environmental quality should improve due to decreases in this insect and decreases in insecticide spraying.

8) Is individually limited but cumulatively has considerable effect upon environment or involves a commitment for larger actions
The proposed action is limited to controlling a significant pest of edible plant species. No cumulative negative effect on the environment is anticipated, nor is there a commitment for larger actions.

9) Substantially affects a rare, threatened or endangered species, or its habitat.
The proposed action will not substantially affect rare, threatened or endangered species or their habitat. The natural enemy is host specific to the medfly in Hawaii. No native, rare, threatened or endangered insects are closely related to its host. Studies by UH demonstrated that the natural enemy will not attack other insect species.

10) Detrimentally affects air or water quality or ambient noise levels.
The proposed action, to release an insect natural enemy, is not anticipated to affect air or water quality or ambient noise levels. Reductions in medfly populations may have a positive local impact on water quality with the decrease in the use of pesticides.

11) Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal water.
The proposed action is not anticipated to have any impact on environmentally sensitive areas.

12) Substantially affects scenic vistas and view planes identified in county or state plans or studies.
The proposed action is not anticipated to affect scenic vistas or view planes.

13) Requires substantial energy consumption.
No substantial energy consumption will be required for this proposed action.

Issues of Uncertainty

Uncertainty regarding the consequence of a subject action requires evaluation as part of an EA. In the case of the proposed project, questions regarding uncertainty were expressed during the consultations.

One concern related to the uncertainty that *F. ceratitivorus* may attack non-target insects. The commenters were satisfied with the evidence in which host specificity studies were conducted on related insects that occur in Hawaii - none served as viable hosts for this natural enemy. In addition, all literature on *F. ceratitivorus* demonstrates that the natural enemy has a very narrow host range. Historically, attacks on non-target hosts by introduced insect biological control natural enemies have not occurred with natural enemies released after 1975. All releases after this date underwent modem host specificity analysis and were reviewed by three expert committees.

Another potential uncertainty relates to the degree to which *F. ceratitivorus* will parasitize medflies. In other words, will this release result in effective reductions in medfly populations? This is difficult to predict. What is known is that *F. ceratitivorus* has shown evidence of efficacy in Israel and Guatemala.

In summary, no action has consequences that are completely predictable, and thus there is a degree of uncertainty weighing risks against benefits. In this case, there is an overwhelming consensus among biologists in Hawaii that medfly is deleterious to agriculture and the public. The uncertainty associated with biocontrol of medfly appears to be low, due to the rigorous testing of this biocontrol agent. Balanced against the certainty of the damage posed by medfly, the levels of uncertainty associated with the proposed action appear negligible.

VII. Final Determination

The University of Hawaii has reviewed the Final Environmental Assessment. The draft EA was published in the Environmental Notice on December 8, 2008. A 30-day public comment period began on December 8, 2008. A single respondent provided comments. The comments were addressed in detail. The University of Hawaii has determined that this project will not have significant environmental effects and has issued a FONSI.

VIII. References

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IX. Appendix

Reply to comments concerning Draft Environmental Assessment for field release of *Fopius ceratitivorus* for the biocontrol of medfly; submitted on December 16, 2008 by Sydney Ross Singer, Director, Good Shepherd Foundation, P.O. Box 1880, Pahoa, HI 96778

What is the size of this parasitoid?
Approximately 3-4 mm.

What is the behavior of this insect?
This insect is a free-living parasitoid in the adult stage that stings medfly eggs.

Do they sting humans?
No.

Are they aggressive to any other species besides medflies?
No.

What do these parasitoids eat? Nothing is mentioned about their food supply.
Adults eat honeydew, flower nectar and pollen, fruit juice, and extra-floral nectary secretions. Larvae eat medflies.

What competition might there be with other species for food?
None.

What about the males? What is their behavior and what do they eat?
They mate with females. Otherwise the same.

What controls the population of these parasitoids? Nothing is mentioned about the natural controls for this parasitoid in its native Kenyan habitat. What controls will there be in Hawaii for burgeoning populations of this insect once released?
Self-limiting regulatory mechanisms based on density dependent feedback cycles; generalist predators.

Since you cannot measure dispersal capability, how can you know what might happen with this insect if released in Hawaii? How high might its populations go? According to the literature, introduced insect populations can skyrocket, and host and food preferences can change at high parasitoid numbers, as the insects look for additional sources of food and hosts for reproduction. Research done in quarantine cannot simulate this situation, and there are no field studies in Kenya to suggest what might happen. This needs to be discussed.
Historically, over the past hundred years, dozens of related species of opine braconids from Africa, Asia, and Australia have been released in Hawaii. There have been no significant non-target impacts. As a specialist on medfly populations, *F. ceratitivorus* will be self-limiting.

What disruption will the introduction of this insect cause to the food web in Hawaii?
None.

What eats the medlfy? Are medflies a food source for native or introduced insectivorous birds, or for the Hawaiian hoary bat? Everything is food for something. Reducing medfly populations may help human agriculture, but harm other species.
There are three other, more abundant species of tephritids that the bats and birds can feast on.

Do these parasitoids sting fruit that does not contain medfly eggs?
No.

Can the parasitoid harm fruit in its process of looking for medfly eggs?
No.

What impact might these parasitoids have on native fruit flies?
None. It is restricted to medfly.

This DEA does not mention or discuss the fact that all insects can evolve quickly and adapt to new food sources. The assumption that current hosts preferences will not change over time is naïve. The risks of this evolution need to be discussed, along with possible new hosts.
No one can predict development trajectories over evolutionary time. In the history of biological control worldwide, there has never been a case of a genetic change leading to novel host use.

The statement in the EA, „None of these other parasitoids with broader host ranges that have been established here for decades have had any significant environmental impactss (sic) in Hawaii‰, is not a justifiable statement. The impacts of these past releases have been poorly monitored, and ripple effects are difficult if not impossible to analyze. This statement is, therefore, more propaganda than fact. Indeed, the biocontrol literature regarding parasitoid use expresses the problem with assessing the negative impacts of these releases.
Please see the following papers published in the scientific literature; the peer-review process is generally considered the benchmark for scientific validity:

Wang, X. G., A. H. Bokonon-Ganta & R. H. Messing. 2008. Intrinsic inter-specific competition in a guild of tephritid fruit fly parasitoids: effect of co-evolutionary history on competitive superiority. Biological Control 44: 312–320.

Bokonon-Ganta, A. H., M. Ramadan & R. H. Messing. 2007. Reproductive biology of *Fopius ceratitivorus* (Hymenoptera: Braconidae), an egg-larval parasitoid of the Mediterranean fruit fly, *Ceratitis capitata* (Diptera: Tephritidae). Biological Control 41: 361-367.

Messing, R. H. & M. G. Wright. 2006. Biological control of invasive species: solution or pollution? Frontiers in Ecology and the Environment 4: 132-140.

Bokonon-Ganta, A. H. & R. H. Messing. 2006. Biological control of tephritid fruit flies in Hawaii with reference to the newly discovered egg-larval parasitoid, *Fopius ceratitivorus* (Wharton). Proceedings of the Hawaiian Entomological Society 41: 361-367.

Bokonon-Ganta, A. H., Ramadan, M. M., Wang, X. G. & Messing, R. H. 2005. Biological performance and potential of *Fopius ceratitivorus* (Hymenoptera: Braconidae), an egg-pupal parasitoid of tephritid fruit flies, newly imported to Hawaii. Biological Control 33: 238-247.

Wang, X. G., A. H. Bokonon-Ganta, M. M. Ramadan & R. H. Messing. 2004. Egg-larval parasitoids (Hym., Braconidae) of tephritid fruit fly pests do not attack the flowerhead feeder *Trupanea dubautiae* (Dipt., Tephritidae). Journal Applied Entomology 128: 716-722.

Wang, X. G. & R. H. Messing. 2004. Potential interactions among pupal and egg-or-larval-pupal parasitoids of tephritid fruit flies. Environmental Entomology 33: 1313-1320.

Wang, X. G., R. H. Messing & R. C. Bautista. 2003. Competitive superiority of early acting species: a

case study of opine fruit fly parasitoids. Biocontrol Science and Technology 13: 391-402.

Wang, X. G. & R. H. Messing. 2003. Intra- and inter-specific competition by *Fopius arisanus* and *Diachasmimorpha tryoni* (Hymenoptera: Braconidae), parasitoids of the Mediterranean fruit fly *Ceratitis capitata* (Diptera: Tephritidae) in Hawaii. Biological Control 27: 251-259.

Wang, X. G. & R. H. Messing. 2002. Newly imported larval parasitoids pose minimal competitive risk to extant egg-larval parasitoid of tephritid fruit flies in Hawaii. Bulletin Entomol. Res. 92: 423-429.

Wharton, R., M. Trostle, R. Messing, R. Copeland, S. Kimani-Njogu, S. Lux, P. Nderitu, & S. Mohammed. 2000. Parasitoids of medfly and related tephritids in Kenyan coffee: a predominantly koinobiont assemblage. Bull. Entomol. Research 90: 517-526.

Jang, E. B., R. H. Messing, L. M. Klungness & L. A. Carvalo. 2000. Flight tunnel responses of *Diachasmimorpha longicaudata* (Ashmead) (Hym.: Braconidae) to olfactory and visual stimuli. Journal of Insect Behavior 13: 525-538.

Duan, J. J. & R. H. Messing. 2000. Effects of host substrate and vibration cues on ovipositor-probing behavior in two larval parasitoids of tephritid fruit flies. Journal of Insect Behavior 13: 175-186.

Duan, J. J. & R. H. Messing. 2000. Effect of *Diachasmimorpha tryoni* on two non-target flowerhead-feeding tephritids. BioControl 45: 113-125.

Duan, J. J. & R. H. Messing. 2000. Response of *Diachasmimorpha kraussii*, a newly-introduced opiine fruit fly parasitoid, to Hawaiian nontarget tephritids. Biological Control 19: 28-34.

Duan, J. J. & R. H. Messing 1999. Effects of origin and experience on patterns of host acceptance by the parasitoid *Diachasmimorpha tryoni*. Ecological Entomology 24: 284-291.

Duan, J. J. & R. H. Messing. 1998. Effect of *Tetrastichus giffardianus* (Hymenoptera: Eulophidae) on nontarget flowerhead-feeding tephritids (Diptera: Tephritidae). Environ. Entomol. 27: 1022-1028.

Duan, J. J., R. H. Messing & M. F. Purcell. 1998. Association of the opiine parasitoid *Diachasmimorpha tryoni* (Hymenoptera: Braconidae) with the lantana gall fly (Diptera: Tephritidae) on Kauai. Environ. Entomology 27: 419-426.

Duan, J. J. & R. H. Messing. 1997. Biological control of fruit fly pests: Estimating non-target effects of introduced opine parasitoids. Recent Res. Develop. in Entomol. 1: 231-241.

Duan, J. J., K. Joshi, M. Ahmad & R. H. Messing. 1997. Evaluation of the impact of the fruit fly parasitoid *Diachasmimorpha longicaudata* (Hymenoptera: Braconidae) on a non-target tephritid, *Eutreta xanthochaeta* (Diptera: Tephritidae). Biological Control 8: 58-64.

Duan, J. J., & R. H. Messing. 1997. Effect of two opiine parasitoids (Hymenoptera: Braconidae) introduced for fruit fly control on a native Hawaiian tephritid *Trupanea dubautiae* (Diptera: Tephritidae). Biological Control 8: 177-184.

Purcell, M. F., J. J. Duan & R. H. Messing. 1997. Response of three hymenopteran parasitoids introduced for fruit fly control to a gall-forming tephritid, *Procecidochares alani*. Biological Control 9: 193-200.

Duan, J. J., M. F. Purcell & R. H. Messing. 1997. Ovipositional responses of three opiine fruit fly parasitoids to gall forming tephritids. Biological Control 9: 81-88.

Duan, J. J. & R. H. Messing. 1996. Risk analysis and decision-making in biological control - A case study with fruit fly parasitoids. Journal of Agriculture and Human Values 13: 1-10.

Duan, J. J., M. F. Purcell & R. H. Messing. 1996. Parasitoids of non-target tephritid flies in Hawaii: Implications for biological control of fruit fly pests. Entomophaga 41: 245-256.

Duan, J. J. & R. H. Messing. 1996. Response of two opiine fruit fly parasitoids (Hymenoptera: Braconidae) to the lantana gall fly (Diptera: Tephritidae). Environ. Entomol. 25: 1428-l1437.

The 2 tables in the DEA are without adequate explanation to be useful. More information is needed. Also, the alleged attachments 4, 5 and 6 are not included in the OEQC information with this DEA. This information should be part of the DEA itself so it can be properly reviewed.
The tables clearly show that *Fopius ceratitivorus* does not attack tephritid flies in flowerheads (Table 1) nor in galls (Table 2) at all.

What are the possible human and non-human health impacts from consuming fruit with the larvae of this parasitoid?
None.

Why is the University of Hawaii both the applicant and approving agency? This is clearly conflict of interest. Since research grants may be involved in this proposal that may benefit the University, a negative determination by the University is highly unlikely.
All state regulations have been followed, pursuant to Chapter 343.

Why has there been no Federal EA for this release? This insect will spread throughout the state, and will go onto Federal land, and should require a Federal EA. Why is this not discussed in the DEA?
The Federal government has already issued a release permit (USDA-APHIS-PPQ No. 69250).

What is the expected cost of this release and its monitoring? What is the funding source for this?
Some tens of thousands of dollars in salaries paid by the University of Hawaii.

There are no alternatives to this release, apart from no release. What about re-releasing some of the already released biocontrol agents, which are already part of the environment? This would mitigate issues around the introduction of a novel species.
This has already been tried, and was ineffective.

Why not use more traps or other current methods that have been shown effective for medfly control?
Traps are not effective, nor sustainable. Pesticides are damaging to the environment.

If these methods are not working well, why not? There should be an analysis of the methods employed.
There is a voluminous literature on tephritid fruit fly control. Other methods are costly, damaging to the environment, or unfeasible.

If prior biocontrol of medfly has not been ineffective, why is this release considered any better, apart from some nebulous hope for synergy? There can just as well be negative ripple effects. We are being asked to assume the risks of introducing yet another alien insect into Hawaii, while the benefits seem fleeting and insubstantial. This needs to be discussed.
None of the other introduced parasitoids have co-evolved with the medfly. Co-evolution leads to tighter

physiological and phenological association. Egg-attacking parasitoids are more effective than larval-pupal parasitoids.

The assumption that this introduction may reduce the need for pesticides is unsupported. If populations of medfly were reduced on a coffee plantation 50-60%, as suggested in the DEA, does that translate into a 50-60% reduction in pesticide use? Or will the remaining 40-50% of the medfly population still require pesticide use of the same magnitude and frequency?
Pesticides are not used in coffee for medfly control.

Will pesticide use affect this wasp?
It depends on the pesticide. Wide spectrum insecticides will kill the wasp.

Will there be any changes to pesticide use to accommodate this wasp in the environment? One would expect an integrated pest management plan would address this issue.
The wasp will become part of the parasitoid guild that varies from crop to crop, where it will become integrated to a greater or lesser extent, and will also help to control medflies on strawberry guava and other weeds that occur off-farm.

Decision and Finding of No Significant Impact for Field Release of *Fopius ceratitivorus* (Hymenoptera: Braconidae), for Biological Control of the Mediterranean fruitfly, *Ceratitis capitata* (Weidemann) (Diptera: Tephritidae), in Hawai'i
December 2016

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), is proposing to issue permits for release of a nonindigenous insect, *Fopius ceratitivorus* (Hymenoptera: Braconidae) into the environment of Hawai'i for biological control of the Mediterranean fruitfly, *Ceratitis capitata* (Weidemann) (Diptera: Tephritidae). Mediterranean fruit fly, or Medfly is one of the most important agricultural pests in the world, infesting hundreds of species of fruits and vegetables. In Hawai'i, it is important both as a direct pest and as a quarantine pest of crops such as citrus, eggplant, guava, loquat, mango, melon, papaya, passion fruit, peach, pepper, persimmon, plum, star fruit, tomato, and zucchini. APHIS must analyze the potential impacts of the release of this organism into Hawai'i in accordance with USDA APHIS National Environmental Policy Act implementing regulations (7 Code of Federal Regulations Part 372). APHIS has adopted an environmental assessment (EA) prepared by University of Hawai'i (UOH) that analyzed 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
Pests, Pathogens, and Biocontrol Permits
4700 River Road, Unit 133
Riverdale, MD 20737

Hawai'i Department of Agriculture
Plant Quarantine Branch
1849 Auiki Street
Honolulu, HI 96819

The UOH EA analyzed the following two alternatives in response to a request for permits authorizing environmental release of *F. ceratitivorus*: (1) no action, and (2) issue permits for the release of *F. ceratitivorus* in Hawai'i for biological control of Medfly. The draft EA was published in the Hawai'i Office of Environmental Quality Control, Environmental Notice on December 8, 2008 for a 30-day public comment period. A single respondent provided comments, which were addressed in an appendix to the final EA. In addition, the public had the opportunity to comment and testify on this proposed release at a State of Hawai'i Board of Agriculture meeting on October 28, 2014. No comments regarding the release of *F. ceratitivorus* were presented at this public meeting.

This APHIS Finding of No Significant Impact pertains to the analysis in the UOH EA of the potential environmental consequences of release of *F. ceratitivorus* into the environment. *Fopius ceratitivorus* is non-indigenous to any State, territory or possession of the United States and therefore subject to the APHIS' National Environmental Policy Act implementing regulations (7 CFR Parts 330 and 372).

I have decided to authorize the PPQ, Pests, Pathogens, and Biocontrol Permits to issue permits for the environmental release of *F. ceratitivorus* in Hawaii. The reasons for my decision are:

- This biological control agent is sufficiently host specific to Medfly and poses little, if any, threat to the biological resources in Hawai'i.

- The release will have no effect on federally listed threatened and endangered species or designated critical habitats in Hawai'i.

- *Fopius ceratitivorus* poses no threat to the health of humans or wild or domestic animals. Although it is a wasp, it is unable to sting humans.

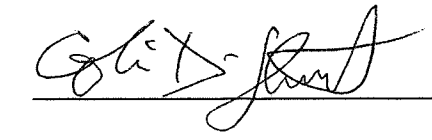
- No negative cumulative impacts are expected from release of *F. ceratitivorus.*

- There are no disproportionate adverse effects to minorities, low-income populations, or children in accordance with Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" and Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks."

- National Historic Preservation Act (NHPA) Section 106, Consultation with Native Hawaiian Organizations, states that agencies must offer to consult with Native Hawaiian Organizations about any actions that may have substantial direct effect. APHIS contacted all organizations and only one response was received. No comments indicated that there would be direct effects on the Native Hawaiian people or organizations.

- While it is unknown whether the release of *F. ceratitivorus* into the environment in Hawai'i would be reversible, there is no evidence that this organism will cause any adverse environmental effects based on the analysis and data in the 2014 UOH EA, and other information provided by the Hawai'i Department of Agriculture and UOH researchers.

I have determined that there would be no significant impact to the human environment from the release of *F. ceratitivorus* in Hawai'i and, therefore, no Environmental Impact Statement needs to be prepared.



12-8-2016

Colin Stewart
Acting Director- Permitting Coordination Compliance
Plant Health Programs
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
U.S. Department of Agriculture

Date