Field Release of *Binodoxys communis* (Gahan) (Hymenoptera: Braconidae) for Biological Control of the melon aphid, *Aphis gossypii* in Hawaii

Draft Environmental Assessment
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Agency contact:

Russell Messing
Department of Plant and Environmental Protection Science
University of Hawaii at Manoa
Kauai Agricultural Research Center
7370 Kuamoo Rd., Kapaa, HI 96746
Tel. (808) 822-4984
FAX (808) 822-2190
email: messing@hawaii.edu

I. Proposed Action

An application was submitted by Dr. Russell Messing of the Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa, Kauai Agricultural Research Center, 7370 Kuamoo Rd., Kapaa, HI 96746, for **renewal of an existing permit** to introduce *Binodoxys communis* (Hymenoptera: Braconidae) into the State of Hawaii under the provisions of Hawaii Revised Statutes, Chapter 141, Department of Agriculture, and Chapter 150A, Plant and Non-Domestic Animal Quarantine. *Binodoxys communis* will be used to control the melon aphid, *Aphis gossypii* (Aphidiidae) an invasive species that is a major pest of several crops in Hawaii.

This Draft Environmental Assessment (DEA) 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 Hawaii Revised Statutes, Chapter 343, Environmental Impact Statements.

II. Need for the Proposed Action

A. Detailed description of proposed action

Purpose of the release

The University of Hawaii proposes to introduce the parasitic wasp *Binodoxys communis* into Hawaii as a biological control agent of the melon aphid, *Aphis gossypii*. The release of this parasitoid is expected to contribute to long-term control of this invasive pest. There are no native or beneficial aphids in Hawaii; therefore the potential for any non-target impacts is minimal.

Binodoxys communis was recently collected in China and introduced to the midwestern U.S.A. for control of the invasive soybean aphid, *Aphis glycines* (Wyckhuys et al. 2007), which is a close relative of the melon aphid. Laboratory studies of this parasitoid in Minnesota have confirmed both its potential as a biological control agent, and its ability to successfully parasitize the melon aphid (Wyckhuys et al. 2007, 2008 a,b).

Need for release

Melon aphid control has also been listed as a high priority industry need by the vegetable and melon industries in Hawaii since at least 1993 (Vegetable and Melons Industry Analysis, Hawaii Farm Bureau Federation). It is also one of the few insect pests of tea, a new crop for diversified agriculture in Hawaii. The Hawaii Dept. of Agriculture includes both melon aphid and banana aphid high on their "Priority List of Arthropods and other Plant Pest Organisms in Hawaii, Revised June 2006." Recently, *A. gossypii* has also been documented to attack at least 12 endemic plant species in Hawaii that are on the Endangered Species List (Messing et al. 2007).

Locations of rearing facilities and release sites

The HDOA Insect Containment Facility (ICF) is located at the HDOA Main Office Complex in the city of Honolulu, on the island of Oahu, in the State of Hawaii. The address of the property is 1428 South King Street, Honolulu, Hawaii 96814-2512. If *Binodoxys communis* is approved for release from the ICF as a biological control agent, rearing of the wasp will be done at the Kauai Agricultural Research Center, 7370 Kuamoo Rd., Kapaa, HI 96746 and on the campus of the University of Hawaii in Gilmore Hall at 3050 Maile Way, Honolulu, 96822. Initial releases will be in fields at the Kauai Agricultural Research Center. Eventually, release sites on all islands will be selected according to aphid infestation levels.

Number/quantity to be released

Inoculative releases of *Binodoxys communis* adults will be made until the parasitoid becomes well established statewide and population densities of aphids can be measured. We estimate a range of several hundred to several thousand wasps for each island.

Timing of release
We hope to make initial releases at the Kauai Agricultural Research Center early in 2009.

Method of release
Adults of *Binodoxys communis* will be released in vials in crops infested with melon aphids, including taro and cucumbers.

Common name and scientific classification
Binodoxys communis (Hymenoptera: Aphidiinae; Braconidae). No common name.

Location of voucher specimens
Voucher specimens of *B. communis* are deposited in the Hawaii Department of Agriculture Taxonomy Unit (1428 South King Street, Honolulu, Hawaii 96814-2512); at the University of Minnesota, Department of Entomology (under the care of Dr. G. E. Heimpel); and with the world's foremost taxonomist in this group, Professor Ptetr Stary (Institute of Entomology; Czech Academy of Sciences; Branisovská 31; 370 05 eské Budjovice; Czech Republic). Additional specimens will be deposited in the University of Hawaii Insect Museum, and the Bishop Museum in Honolulu.

B. Information on the target (host) organism(s)

Classification of target (host or pest) organism
Scientific name: *Aphis gossypii* Glover (Homoptera: Aphididae: Aphidinae: Aphidini)
No synonyms.
Common names: melon aphid; cotton aphid.

Life history of the target organism
This insect has four nymphal stages. Each stage lasts from 1-3 days for a total nymphal period of 4-12 days. Nymphs resemble adults except for their smaller size. They do not have wings.

They feed by sucking sap from their hosts. The undersides of leaves are preferred, other leaf surfaces and flower buds are the next choice, but the entire host may be covered when populations are large. Infested leaves often become cupped downwards and may appear wrinkled. Heavy infestations on some hosts may result in wilting. Young plants can have reduced or stunted growth.

Like other soft bodied insects, aphids produce honeydew, a sweet and watery excrement. Honeydew serves as a medium on which sooty mold grows. Sooty mold blackens the leaf and decreases photosynthetic activity. When found on the fruit, honeydew and sooty mold reduces the marketability of fruits.

Both apterae (wingless) and alate (winged) aphids are able to transmit viruses. Non-persistent transmission occurs when the virus is taken up into the aphid's mouth while feeding on an infected plant and transferred to a healthy plant during the next feeding or probing of mouthparts.

Since winters in Hawaii are mild, there is no need for an over-wintering egg stage. Reproduction does not involve mating and egg-laying. Females give birth to live female nymphs. As a

consequence of this type of reproduction, populations are composed solely of females and there are no males present. There are many generations of this aphid throughout the year in Hawaii (Crop Knowledge Master 2008)

Pest status of pest organism

Melon aphid is Hawaii's most common and destructive aphid. It attacks a wide variety of plants, including asparagus, avocado, banana, burdock, Chinese wax gourd, cucumber, edible gourds, eggplant, flowering ginger, green beans, guava, Hibiscus, hyotan, luffa, orchid, papaya, peppers, potato, protea, pumpkin, spinach, taro, togan, tomato, ti, watermelon and zucchini. Significant weed hosts include lamb's quarters, shepherd's purse, *Malva* and *Bidens*. In addition, it has recently been documented to attack at least 12 endemic plant species in Hawaii's natural ecosystems that are on the Endangered Species List (Messing et al. 2007).

The melon aphid is an important vector of over 50 plant viruses. It is able to vector both P (PRSV-P) and W (PRSV-W) strains of Papaya Ringspot Virus. PRSV-P manifests itself on papaya. PRSV-W does not infect papaya, but does infect cucurbits and watermelon. PRSV-W is also called Watermelon Mosaic Virus 1 (WMV-1). *A. gossypii* also transmits Watermelon Mosaic Virus 2 (WMV-2). Cucumber Mosaic Virus (CMV) is transmitted by more than 60 species of aphids, and the most significant vector is the melon aphid. CMV can be acquired in 5-10 seconds and be transmitted in less than 1 minute. The melon aphid also vectors Celery Mosaic Virus.

C. Biology of organism to be released

Taxonomy

Scientific name: *Binodoxys communis* (Gahan) (Hymenoptera: Braconidae: Aphidiinae)
Synonyms:

Trioxys communis (Gahan 1926)
Trioxys capitophori (Takada & Yamauchi 1979)
Trioxys glycines (Takada & Yamauchi 1979)

No common name

B. communis life history

Dr. Heimpel investigated parasitism rate, adult emergence rate, sex ratio, and development time of *B. communis* attacking *Aphis glycines*, a very close relative of *Aphis gossypii*, under laboratory conditions. Values below are from experiments in which a single mated *B. communis* female was held in a chamber housing a soybean plant with 50 aphids of mixed age. The test was replicated 14 times:

Number of mummies produced:	39.0 $\pm$ 8.4
Mummy emergence rate:	74%
Sex ratio (proportion of females):	0.6
Development time (days):	11.8 $\pm$ 0.4

Natural geographic range of *B. communis*

All records of *B. communis* are from the Eastern Palearctic and Oriental Regions. Countries from which *B. communis* has been recorded include: China, Japan, Korea, Malaysia, Russia and Tajikistan.

A strain of *Binodoxys communis* collected in Taiwan was released into southern California under the name *Trioxys communis* in the early 1960's. It is not clear whether these releases led to

establishment.

Host range of *B. communis*
B. communis has been recorded to attack the following aphid species: *Aphis citricola, Aphis glycines, Aphis gossypii, Capitophorus hippophaes, Rhopalosiphum* sp.

All member of the genus *Binodoxys*, and all members of the sub-family Aphidiinae that have been studied for many years all over the world, are restricted in their host range to aphids.

Parasites/hyperparasites
One hyperparasitoid of *B. communis* is listed in the literature: *Pachyneuron aphidis* (Hymenoptera: Pteromalidae) (Shi 1987). There have been no hyperparasites in the cultures of *B. communis* obtained and reared by Dr. Heimpel in Minnesota; the source of the colony to import to Hawaii.

Status as hyperparasite
Neither *B. communis*, nor any other member in the subfamily Aphidiinae, has ever been recorded to act as a hyperparasite.

III. Alternatives to the Proposed Action

The actions being considered in this EA are (1) No Action (not issuing a permit) or (2) issuing a permit for release of *B. communis*. The No Action alternative will maintain the status quo: *B. communis* will not be imported, and the melon aphid will continue to be a significant pest in Hawaii. This will result in the continued spraying of large amounts of toxic pesticides into the environment. *A. gossypii* has already been shown to have populations with high levels of insecticide resistance (Hollingsworth et al. 1994) – thus stronger and more frequent applications of chemicals will be required.

If a release permit is authorized, the parasitoid will be released on Hawaii's farms, and its efficacy evaluated. There is then the potential for population reductions of the aphid, lower rates of alate production on crops, weeds, and native plants, and a decrease in the spread of plant pathogenic viruses.

IV. Environmental Impacts of the Proposed Action and Alternatives

Potential impacts on human environment
There will be no impact of *B. communis* on the human environment in Hawaii. This parasitoid does not harm humans, animals, or plants. It can only parasitize aphids.

Literature search for other host records
In its native habitat in Asia, the parasitoid has been recorded from *Aphis citricola, Aphis glycines, Aphis gossypii, Capitophorus hippophaes, Rhopalosiphum* sp.

In laboratory tests in Minnesota, the parasitoid could also attack *Aphis asclepiadis, Aphis craccivora, Aphis gossypii, Aphis monardae, Aphis nasturtii, Aphis nerii, Aphis oestlundi, Aphis rumicis, Schizaphis graminum, Aulacorthum solani, Diuraphis noxia, Macrosiphum euphorbiae,* and *Sitobion avenae.* With the exception of *A. asclepiadis* and *A. monardae,* the other species are all invasive pests in Hawaii.

Host specificity in country of origin.

In China, *Aphis glycines* is the most common host (Liu et al. 2004)

Interactions with established biocontrol agents
The following parasitoids of melon aphid are known to occur in Hawaii: *Aphelinus varipes (*Aphelinidae*), Aphidius colemani, Lysiphlebus testaceipes (*Braconidae*),* and *Endaphis fugitiva (*Cecidomyiidae*).* Should multi-parasitism occur in the field (multiple parasitoids attacking the same host), it is not known which one would be the superior competitor. There are also numerous predators that feed on aphids (i.e., lady beetles, syrphids, chrysopids) and these are liable to also eat parasitized aphids. The combined impact of the predators and parasitoids will likely kill more aphids in total than any one natural enemy species alone.

Potential impact on T&E species
There is no possibility of impact on any threatened or endangered species in Hawaii. The parasitoid attacks only aphids, and there are no native aphids in the state.

Impact to related non-target potential hosts
The only non-target potential hosts in Hawaii are other invasive aphid pests. For example, *Aphis citricola* is a pest of citrus, and *Rhopalosiphum* is a pest of corn; these are both potential hosts of *B. communis* in Hawaii.

Potential of *B. communis* to act as a hyperparasite
Neither *B. communis*, nor any other member in the entire subfamily Aphidiinae, has ever been recorded to act as a hyperparasite.

Potential of *B. communis* to attack non-targets
There are no non-targets of concern in Hawaii. *B. communis* can only parasitize aphids. Every single aphid species that occurs in the state is an exotic invasive pest species.

V. Listing of Agencies and Persons Consulted:

The application to release aphid parasitoids in this subfamily in Hawaii was **evaluated for safety and approved** across-the-board by:

1. Hawaii Dept of Agriculture (HDOA) Entomology Sub-Committee
2. HDOA Plants and Animals Advisory Committee
3. Hawaii Board of Agriculture
4. Federal regulatory authorities (USDA-APHIS).

This permit has recently expired and I am seeking a simple renewal.

Bernarr Kumashiro, Insect Taxonomist
Plant Pest Control Branch; Hawaii Department of Agriculture
1428 South King Street; Honolulu, HI 96814-2512
Phone: (808) 973-9522; Fax: (808) 973-9533; email: Bernarr.R.Kumashiro@hawaii.gov

George E. Heimpel
Department of Entomology; University of Minnesota
St. Paul, MN 55108
Tel. (612) 624-3480; FAX (612) 624-5299; email: heimp001@umn.edu

Robert Kula, Research Entomologist
Systematic Entomology Laboratory
Communications & Taxonomic Services Unit
Bldg. 005, Rm. 137, BARC-West
10300 Baltimore Avenue
Beltsville, MD 20705-2350

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Addendum to Draft Environmental Assessment:

Field Release of *Binodoxys communis* (Gahan) (Hymenoptera: Braconidae) for Biological Control of the melon aphid, *Aphis gossypii* in Hawaii

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Russell Messing
Department of Plant and Environmental Protection Science
University of Hawaii at Manoa
Kauai Agricultural Research Center
7370 Kuamoo Rd., Kapaa, HI 96746
Tel. (808) 822-4984
FAX (808) 822-2190
email: messing@hawaii.edu

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(1) Agency submittal letter and anticipated determination.

Please see letter submitted with previous Draft EA. Anticipated determination is a FONSI (Finding of No Significant Impact).

(2) Identification of applicant or proposing agency.

Dr. Russell Messing
Department of Plant and Environmental Protection Science
University of Hawaii at Manoa
Kauai Agricultural Research Center
7370 Kuamoo Rd., Kapaa, HI 96746
Tel. (808) 822-4984
FAX (808) 822-2190
email: messing@hawaii.edu

(3) Identification of approving agency

Not applicable

(4) Identification of agencies, citizen groups, and individuals consulted in making the assessment

(A) Federal permit application was reviewed by the USDA-Animal and Plant Health Inspection Service.

(B) State permit application was reviewed and approved by the Entomology Advisory Sub-Committee, which contains representatives from the following organizations:

- University of Hawaii Entomology Dept.
- Bishop Museum
- USDA-Animal and Plant Health Inspection Service

- USDA-Agricultural Research Service
- Hawaii Dept. of Agriculture Plant Pest Control Branch

(C) State permit application was reviewed and approved by the Plants and Animals Advisory Committee, which contains representatives from the following organizations:

- Hawaii Dept. of Agriculture Plant Quarantine Branch
- University of Hawaii Botany Dept.
- Honolulu Zoo
- Hawaii Institute of Marine Biology

(5) General description of the actions technical, economic, social, and environmental characteristics; time frame, and funding source.

(A) Technical

please see the original Draft EA for details.

(B) Economic

Statewide farm sales for vegetables and melons totaled over 73 million dollars in 2006 (http://www.nass.usda.gov/hi/stats/t_of_c.htm). Most of these crops are attacked by the pest melon aphid. The aphid also is the primary vector of papaya ringspot virus; papaya sales were another 11 million dollars in 2006.

(C) Social

The use of biological control agents to control the pest aphids will reduce the use of toxic pesticides in Hawaii. This will enhance farm worker safety. Improved viability of fruit and vegetable farms in Hawaii will also result in greater employment opportunities and rural community vitality.

(D) Environmental

The use of biological control agents to control the pest aphids will reduce the use of toxic pesticides in Hawaii. The 2006 Hawaii Agricultural Statistics Service (http://www.nass.usda.gov/hi/stats/t_of_c.htm) shows that there are thousands of acres of crops across all the Islands that are hosts of the melon aphid pest, including taro, papaya, melons, squash, cucumber, citrus, etc. Reduction in pesticide use will mean less groundwater contamination, and greater safety for wildlife and beneficial insects.

(E) Time frame

We propose to import and make initial releases of *Binodoxys* starting early in 2009. Once established, the parasitoids should contribute indefinitely to control of the pest aphids, with no further costs or inputs.

(F) Funding source

This project was supported by funds from: The USDA Tropical and Subtropical Agricultural Research Program (T-STAR); the USDA Agricultural Research Service; University of Hawaii Federal Hatch funds.

(6) Summary description of the affected environment…

Initial releases of *Binodoxys* will take place on University of Hawaii land at the Kauai Agricultural Research Station on Kauai. We expect *Binodoxys* to establish

at agricultural locations where susceptible crops are grown and melon aphid populations are persistent.

(7) Impacts to cultural practices and resources

There will be no impact on cultural practices or resources.

(8) Identification and summary of impacts and proposed mitigation measures

There are no impacts anticipated, hence no mitigation measures considered.

(9) Alternatives considered

(A) No action

Maintaining the status quo will lead to continued economic losses to agricultural commodities due to melon aphid infestations. Given the recent finding of aphid attack on endangered native Hawaiian plants, there is also the possibility that large aphid populations from agricultural settings will spill over to attack (and possibly transmit viruses) to plants in natural ecosystems. This could put additional pressure on already threatened plant species.

(B) Chemical control

Chemicals are already used to control melon aphids on many farms. This has led to high levels of insecticide resistance in some populations; and in turn greater rates of chemical application. This is a treadmill that continuously leads to more chemical inputs, higher costs, and more environmental damage. While new chemicals are developed from time to time that have different toxicity profiles, the aphids have proved to be extremely adept at developing resistance mechanisms to a wide range of chemicals.

(C) Biological control

When biological control is successful, the parasitoids contribute to lower population levels of the aphids in most environments. *Binodoxys* can be self-replicating, can search out aphids even at low population densities and in weeds, backyard plants, natural ecosystems and other locations where chemical control is not an option. For a small initial investment, the economic benefits can continue to accrue indefinitely.

Other natural enemies are known which attack melon aphid. However, predators can have a wide host range, and possibly attack other non-aphid species; and pathogens can also be non-specific. *Binodoxys*, and all members of the family Aphidiidae, is host specific, and can only attack aphids.

(10) Discussion of findings and reasons supporting the agency anticipated determination

The proposed importation of *Binodoxys communis* has significant potential benefits, while having minimal risks. Improved biological control of aphids can help sustain Hawaii's farms and rural communities, enhance agricultural

economies, reduce toxic pesticide input to farms and groundwater, and improve farm worker safety.

Binodoxys and all members of its taxonomic family are parasitoids that are completely specific to aphid hosts – they attack no other insects, nor any other animals or plants. Every aphid species that occurs in Hawaii is an exotic, invasive species. Therefore, there is almost no possibility that *Binodoxys* can have any non-target or environmental impact.

(11) List of all required permits and approvals

State of Hawaii Dept. of Agriculture permit number 08-03-K-E343 was approved for 2007; and is currently awaiting renewal pending the outcome of OEQC determination of FONSI.

(12) Written comments and responses to the comments under the early consultation provisions…

(A) from the Advisory Sub-Committee on Entomology:

(1) Dr. Kenneth Teramoto, Hawaii Dept of Agriculture: "*I recommend approval [of the release…]. Because this genus is known to be specific to aphids, and there are no native aphids in Hawaii, I fully support this request.*"

(2) Dr. Frank Howarth, Bishop Museum: recommended disapproval of release based on a simultaneous request at that time for importation of the genus *Aphelinus,* which he stated were "*less than 1 mm long, making species determination difficult, especially with living specimens. The chances of introducing multiple species under one name with each shipment are extremely high. Voucher specimens need to be preserved for each shipment, and the species identity needs to be confirmed for each proposed release*."

RESPONSE: The current request has been more narrowly focused, and does not include the genus *Aphelinus*.

Binodoxys is much larger than *Aphelinus*, and the species determination is straightforward. The origin of the importation is not a mixed population from the field, but rather a known, pure, well characterized and identified laboratory colony from the University of Minnesota. Voucher specimens of *B. communis* are deposited in the Hawaii Department of Agriculture Taxonomy Unit (1428 South King Street, Honolulu, Hawaii 96814-2512); at the University of Minnesota, Department of Entomology (under the care of Dr. G. E. Heimpel); and with the world's foremost taxonomist in this group, Professor Petr Stary (Institute of Entomology; Czech Academy of Sciences; Branisovská 31; 370 05 eské Budjovice; Czech Republic).

Additional specimens will be deposited in the University of Hawaii Insect Museum, and the Bishop Museum in Honolulu.

The species identity was confirmed both by Petr Stary and by Dr. Robert Kula, Taxonomic Specialist at the USDA Systematic Entomology Laboratory, Beltsville, MD 20705-2350.

(3) Dr. David Lance (USDA-APHIS): "*I recommend approval [of the release…]"*

(4) Dr. Mary Purcell (USDA-ARS): "*I recommend approval [of the release…]"*

(A) from the Advisory Committee on Plants and Animals:

(1) Dr. Reimer (Hawaii Dept of Agriculture) recommended that "*All parasitic wasps must be imported into the Hawaii Dept of Agriculture Insect Quarantine Facility and screened for diseases, parasites, and predators before being released.*"

RESPONSE: we agree with this condition.

(2) Dr. Bardach (Hawaii Institute of Marine Biology) asked about the consequences of the release, and was answered by Dr. Reimer that "*aphid populations would decline and that this would be beneficial because all aphids in Hawaii are alien pest species.*"

(3) Dr. Lamoureux (UH Dept of Botany; Director of Lyon Arboretum) recommended that "*all wasps should be positively identified before being released from qurantine*."

RESPONSE: we concur. The source (lab colony) has been identified by two taxonomic experts, and voucher specimens to use as a reference have been sent to Dr. Bernarr Kumashiro, Insect Taxonomist, Plant Pest Control Branch; Hawaii Department of Agriculture. Dr. Kumashiro has agreed to confirm the wasp's identity before release.

(4) Dr. Terry asked what the track record was for this wasp genus, and Dr. Reimer responded that they have successfully suppressed aphid populations.

(5) Dr. Redmann (Honolulu Zoo) asked what preys on the wasps, and will the introduction cause an increase in alien predatory insects and alien bird species? Dr. Reimer responded that the wasps are minute and would probably not be preyed upon by birds, but that alien predators will feed on them. However, predators are not host specific and would benefit little from the introduction of these wasps.

(6) Dr. Redmann asked if there is any biological control of aphids presently [in Hawaii]. Dr. Reimer responded that there is, and that some aphid populations are suppressed by natural enemies, but that the introduction of these wasps would add to the arsenal we have against aphids.

After considering the discussion, as well as comments from the Advisory Subcomittee on Entomology, the Advisory Committee on Plants and Animals voted unanimously to recommend approval of the request.