The Spring *Tiphia* Wasp

A Natural Enemy of Japanese & Oriental Beetle Grubs

Designing & Implimenting Biological Controls Against Exotic Grubs Through Farmscaping

Japanese Beetle *Popillia japonica* & Oriental Beetle E*xomala orientalis*

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Farmscape: Design for Wasps, Think Ahead

The purpose of this guidesheet is to help persons and agencies interested in sustainably suppressing populations of the Japanese and Oriental beetle through natural enemies and food plants. Using habitat modification by planting known food plants that the Spring *Tiphia* wasps favor, we will establish and optimize the wasps' reproductive potential for maximum control of exotic grub populations. By having food plants nearby, a significantly higher rate of parasitization and resultant sustainable suppression of populations of the Japanese and Oriental beetle can be achieved.

Description of Spring *Tiphia* wasps.

The spring *Tiphia* wasp looks very similar to a winged black carpenter ant (Figures 1 and Figure 2), but is more aerodynamic and lacks elbowed antennae, which is characteristic of an ant. The female wasp is heavily set and built for digging in the ground in search of Japanese beetle grubs. Its size can range from 1/2 to 3/4ths of an inch long. The male wasp, which spends its adult life flying in search of female wasps, is more slender and is normally only 3/8ths of an inch long. Male wasps have a tiny hook at the end of its abdomen that is used when mating with the female. The female wasp possesses a stinger and, if handled roughly, can give a mild sting, similar to a sweat bee. However, it does not frequent houses or domestic areas, minimizing contact with people. The wasp is also not aggressive towards humans, and does not normally sting people, as it is solitary and has no nest to defend.

Figure 1. Female Spring *Tiphia* wasp, *Tiphia vernalis* Rohwer, feeding on sugar droplets on a cherry leaf. Female wasps are heavily set and built for digging in the soil in search of their hosts, Japanese and Oriental beetle grubs.

Figure 2. Male Spring *Tiphia* wasp, *Tiphia vernalis* Rohwer, feeding on sugar droplets on a cherry leaf. Compared to the female Spring Tiphia wasp in Figure 1, the male wasps have a more slender abdomen, less heavily set, and very active daytime flyers.

Release Site Steps

1. Determine Your Budget
2. Create A Design
3. Select A Release Site
4. Area With Hosts: JB, OB
5. Adequate Food Plants
6. Site Steward
7. Schedule of Activities
8. Estimate Maintenance

Design Steps

Item	Area	Cost	Total
Planting Food Plants	1 Acre	$400	$400
100 Wasps	1 Acre	Market Price	
Clearing Brush	1 Acre	$200	$2100
Enhance Lawn	1 Acre	$400	$2500

* Avg Cost per Area(Acre) for Release Site Insectrary

Planning & Budget Goals

Through proper life history knowledge, correct site selection, and the presence of the right food plants, we will have successfully chosen and/or modified a selected habitat with exotic grubs as a release site that now has established good numbers of the Spring *Tiphia* on populations of Japanese and Oriental beetles. Due to the presence of the right requisites and food plants, the Spring *Tiphia* has realized good parasitization rates and dropped the level of these pests below economically damaging levels on an area-wide scale. We itemize the necessary requisites that enhance the colonization and establishment of the Spring *Tiphia*.

Release Site Design Tools

Before you start working on the ground, you need to refine your sketch into a measured drawing and lay out all the elements you want to include in your release site. Here are some release site design definitions to help you get started:

- **Space-based Layout**: A release site design that is based on spaces for activities, such as golfing or baseball and position the plants around those spaces.
- **Planting-based Layout**: A release design that is based on the creation of planting beds and develops the leftover space around these for circulation and harvesting of plants.
- **Collecting Area**: A space enclosed by plants, structures, or both and used for collecting wasps, similar to a room inside your house.
- **Planting Patch**: Food Plants grouped to create a continuous mass, with a regular or irregular outline. Planting beds are patches, as are groves of trees.
- **Corridor**: A linear space, enclosed or edged, that allows movement of wasps along or within the space.
- **Edge**: A continuous element that encloses or defines an area, such as a row of low plants, a fence, or a stone widow.
- **Gateway**: An access point or opening, usually through a barrier such as a hedge, fence, or wall, that serves as an entrance to garden rooms or corridors.
- **Focal Point**: A strategically placed item of interest, such as an ornamental plant or a statue, that draws the eye through the design of the surrounding elements

Spring Tiphia Annual Life Cycle Diagram

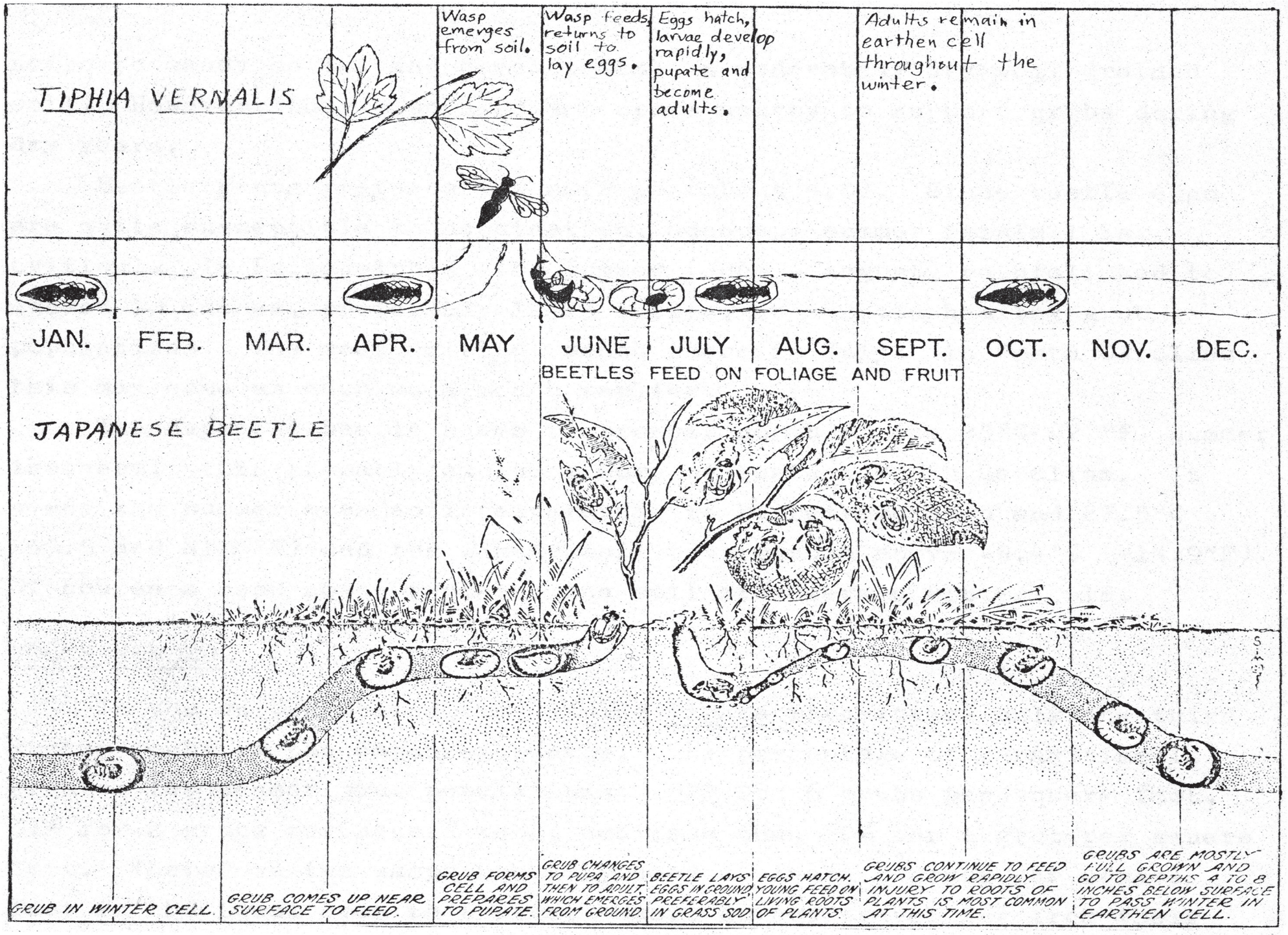

Figure 3. The Lifecycle of *Tiphia vernalis* attacking the Japanese beetle in the mid-Atlantic states.

Spring *Tiphia* Life Cycle (A Mated, Well Fed Female wasp is Most Important – they lay female eggs & perpetuate the species)

The spring *Tiphia* normally emerges when bridal wreath spirea and forsythia are in bloom. After a period of feeding and mating (Fig. 4) on food plants, the female wasp begins to hunt for Japanese or Oriental beetle grubs to parasitize.

The female Spring *Tiphia* wasp is able to detect the presence of grubs in an area by scent, and burrows into the ground in search of a grub. Once she finds a grub in its earthen cell, a brief struggle ensues. The grub tries to fight off the wasp and will even use a piece of soil to try and block the wasp from attacking. But the female wasp will usually not be denied. She stings the grub on its underside, in the center between the pairs of legs, at the cephalothoracic ganglion (Fig. 5). This causes a temporary paralysis of the grub that lasts about 30 minutes.

Figure 4. Mating pair of Spring *Tiphia*, *Tiphia* vernalis Rohwer wasps on Norway Maple leaves. Norway maple hosts aphids and the honeydew from these aphids is known to be attractive to *Tiphia* wasps.

Figure 5. A female *Tiphia* wasp stinging a 3rd instar grub between the legs, temporarily paralyzing it. Usually this happens below ground; we removed soil to show the wasp in action. The now paralyzed grub allows the female wasp to rasp an area directly behind the legs, and attach an egg to this rubbed area.

While the grub is paralyzed, the wasp prepares an area on the underside of the now paralyzed grub between the thorax and abdomen to receive a single egg. She rasps the area with the tip of her abdomen (pygidium) and kneads it with her mandibles, then attaches an egg to this softened spot. By wearing away the membrane of the grub and making it thinner, the wasp larva, which hatches about 7 days later, will have little problem piercing through the skin of the grub in order to feed (Fig. 6). The female wasp can normally parasitize 1 to 2 grubs daily in this manner, and can lay a total of between 40 and 80 eggs over her lifespan of 30 to 40 days.

The female wasp can selectively fertilize her eggs. If the grub is a healthy 3rd instar, she will lay a fertilized egg, which develops into a female wasp. However, if the grub is a 2nd instar, is weak, or has some defect detected by the wasp, she will then lay an unfertilized egg, which develops into a male wasp. Thus, it is important to have mated female wasps as unfertilized female wasps will lay only male eggs and the population will go extinct in that area.

Figure 6. Egg of *Tiphia vernalis* located in the suture between the third thoracic segment (T3) and the first abdominal segment (A1). The location of the egg is characteristic for the Spring *Tiphia* and can be used as an identification tool. The egg hatches after about 7 days. The wasp larva can then more easily pierce this prepared area and begin feeding on the grub's body fluids.

Once the spring *Tiphia* wasp egg hatches, the larva begins to feed on the grub, and the grub rapidly becomes weakened and ceases to feed (Fig. 7). The wasp larva grows rapidly and consumes the entire body of the grub except for the head capsule in a matter of 7 to 10 days or less, depending on soil temperatures. The beetle grub now completely consumed, the spring *Tiphia* wasp larva then spins a waterproof brown cocoon in the earthen cell of its former occupant, and enters the pupal stage.

The spring *Tiphia* wasp pupa then transforms into an adult wasp within the cocoon in late summer or early fall (Fig. 8). The wasp then overwinters safe inside its waterproof cocoon until the Spring, when it chews its way out of the cocoon and emerges from the soil to start the life cycle over again.

Figure 7. Spring *Tiphia* wasp larva feeding on a third-instar Japanese beetle grub in the characteristic spot behind the last set of the grub's legs. The wasp larva will continue to feed on the grub, consuming all body parts, except the head capsule. The wasp larva's feeding takes 7-10 days before the grub is killed. The wasp larva then spins a cocoon to overwinter.

Figure 8. The Spring *Tiphia* larva has completed feeding on the Japanese (or Oriental) beetle grub, and spins a waterproof brown cocoon. By late summer or early fall the larva has molted into an adult wasp. The wasp remains in the brown cocoon overwinter until the following Spring. It then chews a hole in the cocoon and emerges from the soil.

Selecting the Correct Release Site: Designing the right release site for the Spring *Tiphia* Is MOST IMPORTANT

The spring *Tiphia* wasp needs four factors for a successful release. The potential release area can be surveyed to determine how many Japanese beetle grubs per square foot are present. By doing some preliminary survey work, you will be able to select an area that has a balance between having the correct food plants and having the most grubs, which will give you the best chance for establishment of the spring *Tiphia*. They are:

1) An area that contains an **abundant supply of its host,** (which is the 2nd and 3rd instar Japanese beetle or Oriental beetle) as a future field insectary;

2) **Adequate WASP food plants** to enable the wasps to mate and realize their reproductive potential (see List of Food Plants on the next page);

3) **High and low ground** to ensure continuance of the grub population in both wet and dry years and most importantly; windows.

4) **Site steward(s)** (landowners, golf course superintendents, park rangers, or similar) that can protect the release site from human caused disturbances like road building, logging, excessive mowing, or spraying of pesticides that would be detrimental to the wasp's survival and increase.

Studies by USDA researchers found that percentage of parasitization was greater for more dense grub populations: 57% for 6 grubs per square foot; 31% for 2 grubs per square foot; and less than 20% for one grub per square foot. **However, these percentages could be increased by farmscaping food plants into the areas where beetle grubs consistently occur, such as golf courses, parks and the areas surrounding airports.**

Pre-release: Sampling Grub densities.

Ideally, you should have 2 to 6 grubs per square foot in an area with ample food plants nearby (300 feet maximum). We have established the Spring *Tiphia* in areas with 2 grubs or less per square foot. Grid off the potential area being considered for release. If you have a large area, such as a golf course or a park, you will want to make several sample sites to determine which has the most grubs with food plants nearby. Each potential survey area can be gridded into a 30-foot by 30-foot square grid. Each section in the grid is a 10-foot by 10-foot piece, for a total of 9 ten-foot square areas. The overall grid pattern looks like a tic-tac-toe drawing.

Take one soil sample from the center of each of the nine squares. Each soil sample should be 1-foot square and at least 6 to 8 inches deep. Count all the grubs in each soil sample. By looking at the raster pattern on the rear of each grub, you can determine if the grub is a Japanese beetle grub. Do this sampling pattern for each area under consideration for release of the *Tiphia* wasp.

Once you have completed the soil sampling for each area, you will know how many grubs per square foot are present. By selecting an area with the highest number of grubs, you will ensure that the spring *Tiphia* has every advantage in order to become established in the desired area.

List of Food Plants Known to Be Utilized by *Tiphia vernalis:*

Peonies, Chinese peony; *Paeonia lactiflora; Paeonia spp.*
Choke Cherry, *Prunus virginiana*
Norway Maple, *Acer platanoides*
Pine trees, *Pinus spp.*
Tulip Poplar, *Liriodendron tulipifera*
Forsythia, *Forsythia suspensa*
American Elm, *Ulmus americana*
Pyracantha, *Pyracantha spp.*

Collecting Spring *Tiphia* wasps.

A. Weather requirements – sunny, dry, temperatures in the mid-60s to mid-70s degrees Fahrenheit, light wind to carry scent of sugar to attract wasp

B. Spring *Tiphia* Collection Equipment:
Garden gloves - for digging/soil samples
1-gallon plastic pitchers – to hold captured wasps (50-100 per pitcher) with a funnel to prevent wasp escape
4-dram vials – several dozen of these; to catch individual wasps, transfer to pitcher
biomailers – overnight wasps to selected locations
camera – document collection procedures and sites
computer – recording collection data and locality; other obsevations
field journal – record data and field observations
coolers – keep wasps cool (not frozen!) when transporting
freezer packs/blue ice – maintain cool temperature of pitchers with wasps
granular sugar (white is best) – attracts wasps for collection
Hand sprayers – apply sugar water to broad leaved plants
hats – sun, wind, and vegetation protection
ID keys – raster patterns for grubs encountered to identify to species
Dissecting scope – examine close up grubs, wasps, phoretic mites, other items

local maps (county and others)
measuring cup for sugar/water mixtures
nets – aerial, sweep, & beat nets, plus extensions
cages - for feeding wasps, experiments or sting setups
sample sheets - data collection records
shovels - soil samples to determine grub presence & density
soil tins - sting setup with grubs
Sphagnum peat moss – put into soil tins; also use for wasp transport
Sunglasses - UV eye protection
Sunscreen – UV skin protection
thumb counters – keep track of number of wasps collected
static wasp traps – we experiment with other ways of attracting wasps
water – clean water for sugar solutions, water picks for vegetation, and drinking
paperwork - pertinent release paperwork and/or permits (AD-943, PPQ 526s or Federal/State/Local Park permit authorizations)
Tiphia information for public - this guidesheet
Business cards – contacts for public and stakeholders
Office Kit – tape, rubber bands, glue, binder clips, scissors, stapler, ruler, etc.
Clipboards – data sheet recording

4. Spring *Tiphia* Collecting technique.

We have been able to collect wasps from mid-morning all the way through late afternoon on sunny days. Later in the season, there will be less male wasps present and the female wasps will spend more time hunting grubs and less time on foliage (wasps become progressively harder to catch as season progresses).

10% Sugar Water Method: Prior to collecting, make a pitcher(s) with 1 to 2 inches of peat moss at the bottom, plus add several broad-leaved foliage LIGHTLY sprayed with 10% sugar water. You will need one of these pitchers per 100 wasps. **Place in dark shaded area** in field or vehicle **out of sun or indirect light** in order to keep captured wasps **cool and calm**.

Spray 10% sugar water on broad-leaved plants along the collecting area. Do several foliage sprays in concentrated areas in a circular walking pattern so you are not spread out all over the place chasing wasps. It takes an hour or more (depending on wind currents) under good weather to attract wasps. Keep applying sugar water as it dries; once or twice an hour. Our walking circles are ¼ to ½ mile in a loop. You will use lots of sugar and water, bring plenty of clean water to spray.

Walk your circle of plants, and collect any female wasps that come in a 10-dram vial or aerial net. Transfer wasps in the net to a 10-dram vial. Immediately keep any captured wasps out of direct or indirect sunlight in the vials, or they will die from temperature abuse. Transfer these wasps immediately to the pitcher, which is sitting in a SHADED area on or near your circle. Continue until you get enough wasps or few wasps are responding versus effort put forth. 100 Female Wasps is considered a good release number.

Figure 9. Ben Puttler captures a female *Tiphia vernalis* in a 10 dram vial at Meramec State Park during late May of 2017.

Figure 10. *Tiphia vernalis* female in collection jar with sugar water on beech leaves and peat moss substrate.

Holding, feeding, & transporting Spring *Tiphia* wasps

Holding, feeding, & transporting Spring *Tiphia* wasps. Place all captured female wasps into the 1-gallon pitcher, which has been provided with peat moss, allowing the wasps to burrow. The foliage in the pitcher has been lightly sprayed to provide wasps with water and sugar. Another feeding method is to place a saturated wick of 10% sugar water along the side of the pitcher or attached to the foliage. Keep cool and out of the sun; temperature abuse is the main culprit to avoid.

Releasing Spring Tiphia wasps. 100 female Spring *Tiphia* wasps an adequate number to colonize and establish at most release sites intially. Prior to the wasp release, lightly spray foliage in the release area with 10% sugar water. This gives the wasps some food, and induces them to stay in the area, rather than disperse. Take photos and other data records of the area for future reference, especially grub counts and photos of potential food plants that can be used as monitoring sites later.

Post Release Monitoring: Monitor for the presence of both parasitized grubs for parasitization rate studies, and also by attracting adult wasps in the subsequent Spring seasons after release. It is common not to find wasps initially as they make take several years to build to a point where they can be detected with sugar water.

Figure 11. Releasing *Tiphia* vernalis females from the collecting jar at the new site.

Holding, feeding, & transporting Spring *Tiphia* wasps (continued)

Evaluating Spring *Tiphia* Through Parasitization Rates. In order to determine the parasitization rate of the spring *Tiphia* on the Japanese or Oriental beetle, soil sampling must be done in a manner similar to that described earlier. Between 25 and 40 soil samples are normally taken. The timing of the survey work for parasitization rates is of utmost importance. The survey must occur between the time that the spring *Tiphia* has ceased its egg laying activities, and before the Japanese beetles begin to emerge as adults. Normally, this is a 7- to 10-day period, and usually occurs in mid-May in central NC and early to mid-June in the mountains of western NC. Due to the brevity of this period, only a certain amount of sampling can occur each year.

By digging up Japanese beetle grubs and pupae, you can examine each one to determine if the spring *Tiphia* has been active. You may find grubs, grubs with *Tiphia* larvae attached, *Tiphia* cocoons, or Japanese beetle pupae. The number of grubs and pupae that have no sign of spring *Tiphia* attack are compared to the number of parasitized grubs and Tiphia cocoons found in a particular area. This ratio will give an indication into the relative percentage of parasitization of a particular population of the Japanese beetle.

Another indication of the relative effectiveness of the spring *Tiphia* at established sites is the large numbers of adult wasps seen flying on sunny days. Each wasp has developed at the expense of a Japanese beetle grub. Large numbers of these wasps flying about suggests that the parasites may be of much greater benefit than is usually thought.

Post-Release Monitoring for Wasp Adults. Monitor for the presence of *Tiphia* wasp adults the next Spring season after releases by following the same procedures used to collect wasps. Spray a 10% sugar water solution on broad-leaved plants in the release area during April-June. We have seen this vary by as much as 6 weeks in the field in northwestern North Carolina. A cold Spring will delay emergence of the wasps into early June; likewise, a warm winter and Spring will hasten the emergence of the wasps in April.

Key out the captured wasps, or isolate females with a JB/OB grub overnight in a soil tin, and see if the grub is parasitized the next day. If there is a wasp egg in the suture between the third thoracic segment (T3) and first abdominal segment (A1) then that wasp is a Spring *Tiphia* wasp.

Record Keeping. Each release of Spring *Tiphia* wasps into a new area should be recorded in a central database, so that the wasp colony can be protected from disturbances and resources can be efficiently used. Some of the information recorded should be: Program: Japanese beetle biocontrol; County; Species: *Tiphia* vernalis Rohwer; Number released; Released By; Release ID number; Life stage released (adults (A), larva (L), eggs (E)); Source of release material; GPS coordinates (note GPS data type: DDM, UTM, etc.); Date and Time of release; Location details at time of release; Nearby Food Plants and Flora; Host/alternate host abundance: Japanese or Oriental beetle grubs/area; Contact number/ information for Steward of Site; Comments:

Meteorological Conditions for release – Wind; Temperature; Lighting; Humidity, Rain, etc.

Dedication:

This manual is dedicated to all the past, present, and future USDA, state, private, and foreign personnel that have assisted or will assist in the establishment of any of the of any of the natural enemies of exotic scarab beetles. This includes but is not limited to, the Spring Tiphia, *Tiphia vernalis*, the Winsome Fly, *Istocheta aldrichi* (Mesnil), the Summer/Fall *Tiphia*, *Tiphia popilliavora*, Milky Spore (*Paenibacillus spp.*), nematodes, and microsporidia. It is hoped this manual is a step towards interation of these natural enemies into a comprehensive biologically based IPM program against the JB and OB in the Midwest and Western U.S.

Reference: KING, J. L., AND L. B. PARKER. 1950. The Spring Tiphia, an Imported Enemy of the Japanese Beetle. Publication E-799, USDA, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine. 8 pp.

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