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Integrated Pest Management of Japanese Beetle in North Dakota

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Introduction

The Japanese beetle, *Popillia japonica* Newman, belongs to the insect family Scarabaeidae. It is a highly destructive plant pest that feeds on more than 300 host plants, including field crops (especially corn and soybeans), ornamental trees and shrubs, garden flowers and vegetables, and turf (lawns, pastures and golf courses). Some of the preferred host plants of adult beetles found in North Dakota are rose, apple, black cherry, cherry, flowering crabapple, plum, grapes, hollyhock, blackberry, raspberry, linden, elm and buckeye. Grubs are found primarily in the root zones of grasses.

Once established, it can be a difficult and expensive insect pest to control. Control costs for Japanese beetle are estimated at approximately $450 million each year in the U.S.

The Japanese beetle first was detected in North Dakota in 2001 in Bismarck, but it did not become established. In 2012, the Japanese beetle was detected at several locations in North Dakota, including Bismarck, Fargo, Grand Forks, Minot, Oakes, Taylor, West Fargo and rural Foster County. Upon investigation, the source of the infestation was identified as one nursery that shipped Japanese beetle-infested nursery stock into North Dakota.

At this time, whether any Japanese beetle will become established in North Dakota is unknown.

Distribution

The Japanese beetle is native to Japan and also is found in China, Russia, Portugal, Canada and the U.S. It first was discovered in the U.S. in 1916 in New Jersey, where it was introduced accidently from Japan. Now it is established in most states east of the Mississippi River and in Kansas, Iowa, Minnesota, Montana, Nebraska, Oklahoma and South Dakota.

Japanese beetle detection trapping has been conducted in North Dakota since 1960. Some of the potential reasons the Japanese beetle has spread in the U.S. is the favorable climate, easy availability of host plants, lack of natural enemies, natural movement of adults and movement via interstate commerce.

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Identification

Adult: The adult Japanese beetle (Figure 1) is oval-shaped and approximately ½ inch (14 millimeters [mm]) long and ¼ inch (7 mm) wide, although some variation in size occurs. The head and thorax are metallic green, and the wing covers are typically coppery-brown bordered with green. Some individuals have coppery-purple wing covers. The antennae form a club at each end. Five patches of white hairs protrude from each side of the abdomen, and one white patch is present on each side of the last abdominal segment. This combination of traits can be used to separate Japanese beetle from other similar scarab beetles, such as the false Japanese beetle (*Strigoderma arbicola*), and other green plant-feeding beetles in our area.

Egg: Eggs are cream-colored and usually round or oval with a diameter of 0.06 inch (1.5 mm).

Larva: Japanese beetle larvae (grubs) are C-shaped and creamy white with a brown head capsule, have three pairs of legs and are about one inch (25 mm) long when mature (Figure 2). They are difficult to identify because they are similar in appearance to other scarab grubs, such as June beetle grubs (*Phyllophaga spp.*). Grubs are identified using the pattern of hairs (rasters) that form a V just below the anal slit on the end of the abdomen (Figure 3). A 10-power hand lens can help see this pattern. This beetle has three larval instars.

Pupa: The pupa is an earthen cell in the soil formed by the last larval instar. It is about ½ inch (14 mm) long and ¼ inch (7 mm) wide, and cream to metallic green depending on the maturity.

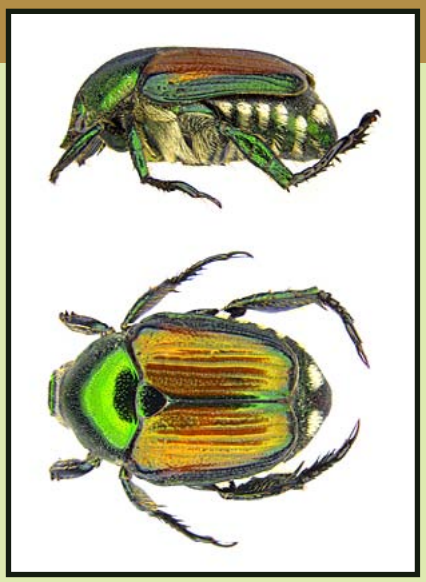


Figure 1. Japanese beetle adult (P. Beauzay, NDSU Extension Entomology)

Figure 2. Japanese beetle larva (D. Cappaert, Michigan State University, www.Bugwood.org)

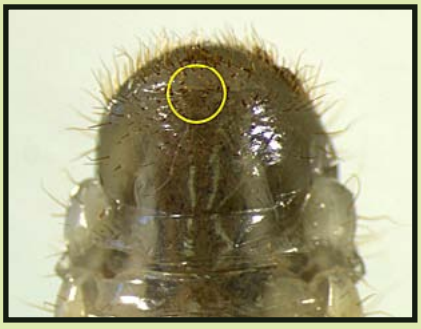


Figure 3. V-shaped raster pattern on last abdominal segment of Japanese beetle larva (Mike Reding and Betsey Anderson, U.S. Department of Agriculture-Agricultural Research Service, www.Bugwood.org)

Life Cycle

The beetle usually has one complete generation per year. However, in cooler climates, completing the life cycle may take two years.

In more northern states, adults emerge from early July through early August and live from four to six weeks. Males emerge a few days earlier than females. As soon as the females emerge, they release a powerful sex pheromone to attract males for mating (Figure 4).

Adult beetles feed on the foliage of trees, shrubs and vines. Female beetles select an egg-laying site, usually in nearby grass areas, including pastures, lawns, golf courses and cemeteries. Eggs are laid in the soil about 2 to 4 inches (5 to 10 centimeters) deep, and one to three eggs are deposited per site. Females lay a total of 40 to 60 eggs during a two- to three-week period.

Figure 4. Japanese beetles mating (C. Elhard, North Dakota Department of Agriculture)

Eggs hatch in 10 to 14 days. Larvae develop through three instars feeding on grassy roots and organic matter. The first instar feeds for two to three weeks and then molts into the second instar, which continues feeding for three to four weeks before molting into the third instar by mid-September.

As the soil temperature cools to about 50 F (10 C), third instar larvae move downward in the soil for overwintering. The following spring, larvae move back up and continue feeding in the grass root zone for four to six weeks until pupation. Pupae mature in about one week, and adults will start emerging in late June to continue the cycle. Adults are active during the day and can fly up to one-half mile (805 meters).

Damage

Adult beetles feed between the veins, giving the plants a skeletonized appearance (Figure 5). Delicate leaves and petals of roses can be completely consumed (Figure 6). The beetle-damaged leaves act as an aggregation site and draw in hundreds of beetles. Figure 7 shows severe foliar defoliation on buckeye by Japanese beetles.

Grubs feed on the roots and root hairs of grasses and sometimes nursery stock, corn, beans and tomatoes. Grubs are a major pest in pastures, lawns, golf courses and cemeteries. Damage symptoms appear as plant wilting, yellowing and even death. The root feeding also reduces the ability of the plant to take up water and tolerate other stresses, such as drought.

Severely damaged turf can be rolled back easily where roots were severed from grub-feeding injury. Secondary turf damage can occur from animals such as skunks and raccoons feeding on the grubs, often destroying the turf (Figure 8).

Figure 5. Leaf skeletonizing on linden (S. Katovich, USDA Forest Service, www.Bugwood.org)

Figure 6. Japanese beetle damage to rose (C. Elhard, North Dakota Department of Agriculture)

Figure 7. Severe defoliation on buckeye (S. Katovich, USDA Forest Service, www.Bugwood.org)

Figure 8. Secondary turf damage by animals feeding on grubs (M. Klein, USDA Agricultural Research Service, www.Bugwood.org)

INTEGRATED PEST MANAGEMENT

Monitoring

Because no one knows whether the Japanese beetle will become established, monitoring for Japanese beetle adults is extremely important. Monitoring is best accomplished by the use of traps (Figure 9) developed specifically for Japanese beetles (see **Trapping** in the **Cultural Control** section).

Trapping in areas of recent detection can confirm whether the Japanese beetle overwintered successfully. Trapping in areas where the Japanese beetle has not been found can document new infestations. In both cases, focused control efforts can be applied to eradicate Japanese beetles or limit them to isolated areas if eradication efforts prove unsuccessful.

Traps are put out prior to adult emergence. Predicted emergence times for North Dakota are near early July. Emergence timing depends on the spring and early summer soil temperatures: Warm temperatures lead to earlier emergence and cool temperatures facilitate later emergence.

Figure 9. Japanese beetle pheromone trap
(C. Elhard, North Dakota Department of Agriculture)

Cultural Control

Trapping is a cultural control strategy that produces mixed results. Japanese beetle traps (Figure 9) contain floral attractants and the female sex pheromone to lure in adult beetles of both sexes. Thus, trapping can reduce adult feeding damage and egg-laying. The attractants can lure in beetles from about 0.62 mile (1 kilometer). However, traps attract about 25 percent more beetles to an area than are trapped. The result is potentially more beetles feeding on nearby plants.

However, if establishment has occurred in North Dakota, it is probably in small, known areas. If this is the case, then trapping may be an effective strategy for eliminating or containing establishment to these areas. In this scenario, trapping will be most effective when many traps are placed throughout the suspected infested area. Traps should be distributed in mid- to late June.

Traps should be monitored at least weekly throughout the adult flight period. Traps that are cleaned and maintained with fresh lures on a regular basis are more effective than traps that are neglected.

Habitat modification is another cultural control strategy. Habitat modification involves the use of plants that are resistant or unattractive to Japanese beetle adults. In Table 1, ornamental woody plants commonly grown in North Dakota that are resistant (or unattractive) and susceptible to adult feeding, with 5 being the most resistant and 1 being most susceptible, are listed. The table is modified from tables in Held (2004), “Relative Susceptibility of Woody Landscape Plants to Japanese Beetle,” Journal of Arboriculture 30(6), pp. 328-335.

Table 1. Resistant and susceptible woody ornamentals commonly grown in North Dakota.

Resistant or Unattractive		
Common Name	**Rating**	**Scientific Name**
Arborvitae	4	*Thuja occidentalis*
American bittersweet	5	*Celastrus scandens*
American elder	4	*Sambucus canadensis*
American hazelnut	4	*Corylus americana*
Black locust	4	*Robinia pseudoacacia*
Boxelder	4	*Acer negundo*
Bur oak	4	*Quercus macrocarpa*
Burning bush	4	*Euonymus alatus*
Dogwood	5	*Cornus spp.*
European cranberrybush	4	*Viburnum opulus*
Forsythia	5	*Forsythia spp.*
Hydrangea	5	*Hydrangea spp.*
Juniper	4	*Juniperus spp.*
Lilac	5	*Syringa vulgaris*
Paper birch	5	*Betula papyrifera*
Pear	4	*Pyrus communis*
Pine	5	*Pinus spp.*
Rhododendron	4	*Rhododendron spp.*
River birch	4	*Betula nigra*
Silver maple	5	*Acer saccharinum*
Spruce	5	*Picea spp.*
White poplar	5	*Populus alba*
Yew	5	*Taxus spp.*
Susceptible		
American cranberrybush	3	*Viburnum trilobum*
American elm	1	*Ulmus americana*
American linden*	1-3	*Tilia americana*
American mountain ash	1	*Sorbus americana*
American plum	1	*Prunus americana*
Apple	1	*Malus spp.*
Black walnut	1	*Juglans nigra*
Buckeye	2	*Aesculus spp.*
Chokecherry	3	*Prunus virginiana*
Crabapple*	1-3	*Malus spp.*
European white birch	2	*Betula pendula*
Grape	1	*Vitis spp.*
Hawthorn	3	*Crataegus spp.*
Larch	2	*Larix spp.*
Lombardy poplar	1	*Populus nigra*
Norway maple	1	*Acer platanoides*
Rose	1	*Rosa spp.*
Sugar maple	3	*Acer saccharum*
Willow	2	*Salix spp.*

*Susceptibility variable depending on variety.

Biological Control

Nematodes are an effective biological control agent of grubs. The species *Heterorhabditis bacteriophora* and *Steinernema glaseri* are commercially available. These species actively seek and attack grubs. Another commercially available species, *Steinernema carpocapsae*, is less active and may not give comparable control.

Treatment timing should coincide with the end of the adult flight period (August). Applications are made to the soil and should be made near dawn or dusk when daily temperatures are relatively low. Treated areas should be watered before and after application, and periodically through the remainder of the season, to ensure that the soil habitat does not become too dry.

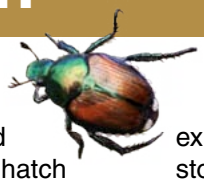
Nematodes have a short shelf life, so be sure to apply them as soon as they are received. Recent studies have demonstrated a synergistic effect between *H. bacteriophora* nematodes and the insecticides imidacloprid and chlorantraniliprole.

When purchasing nematodes, be sure to read the label to make sure you are purchasing the proper species.

Milky spore disease affects grubs and is caused by the bacterium *Paenibacillus popilliae*. Grubs become infected when they ingest the bacterium. Ingestion of the bacterium causes fat depletion and leads to mortality. Infected grubs have milky-white body fluids.

Research has demonstrated that the use of milky spore disease often does not provide adequate grub control. This may be due to a lack of persistence of the bacterium in the soil and/or loss of virulence. **No milky spore disease products are registered for use in North Dakota.**

Insecticidal Control



Proper insecticide application timing is critical to achieve maximum control of Japanese beetle adults and grubs. Because the Japanese beetle is not yet established in North Dakota, when adult emergence would begin is not known. In Minnesota, adults typically emerge in early July, and this timing should be close to what we could expect in North Dakota.

Adults can be controlled with a number of foliar-applied insecticides (Tables 2 and 3). Foliar application should commence when adult beetles are first observed feeding. Foliar-applied insecticides do not offer season-long protection, and multiple applications may be needed during the adult flight period.

The synthetic foliar-applied insecticides listed in Table 2 offer residual control that should last about two weeks. The botanical insecticides listed in Table 4 may offer only three to four days of residual activity. Azadirachtin may act as a feeding deterrent only and not cause adult mortality.

Systemic insecticides for adult beetle control are available as soil-drench and tree-injection applications to protect ornamental trees and shrubs, including roses. Systemic insecticides offer season-long control but take longer to work because the insecticide first must be absorbed and translocated through the plant. Systemic insecticides should be applied at least one month prior to adult emergence.

Grubs are best controlled in late summer after egg hatch has begun and before grubs burrow deep into the soil to overwinter. Grub control in the spring may not be effective because the grubs are larger and feeding is less extensive.

A wide range of long-lasting systemic grub-control products are available. Be sure to apply grub-control products over the entire lawn. A number of grub-control products are available to nurseries to treat existing bagged or potted nursery stock, and to treat soil before plants are bagged or potted.

The following tables list insecticides registered for use in North Dakota for control of Japanese beetle adults and larvae. Table 2 lists insecticides available to homeowners for use on lawns, fruit trees, ornamental trees and shrubs, and vegetable gardens. Table 3 lists insecticides available to professional applicators for use in residential areas, nurseries, sod

Table 2. Insecticides for use by homeowners for control of Japanese beetle.

Active Ingredient	Example Trade Name(s)	IRAC Group	Adults	Grubs
acephate	Ortho Systemic Insect Killer	1B	O	
beta-cyfluthrin + imidacloprid	Bayer Advanced Complete	3A + 4A	L, O	L
bifenthrin	Ortho Bug-B-Gon Max	3A	F, L, O, V	
carbaryl (granular)	Ortho Bug-B-Gon	1A		L
carbaryl (liquid)	Bayer Advanced, Bonide	1A	F, O, V	
chlorantraniliprole	Scott's GrubEx	28		L
cyfluthrin	Bayer Advanced Powerforce	3A	F, L, O, V	
esfenvalerate	Ortho Bug-B-Gon Garden & Landscape	3A	O, V	
halofenozide	Spectracide Grub Stop	18		L
imidacloprid (granular)	Bayer Advanced Grub Control	4A		L
imidacloprid (granular)	Ferti-Lome Tree & Shrub Systemic	4A	O	
imidacloprid (liquid)	Gordon's Grub No More	4A		L
imidacloprid (liquid)	Ortho Max Tree & Shrub Insect Control	4A	O	
lambda-cyhalothrin	Bonide DuraTurf	3A	L	L
lambda-cyhalothrin	Spectracide Triazicide	3A	L, O, V	
malathion	Ortho Max Malathion	1B	F, O, V	
malathion + carbaryl	Gordon's Liquid Fruit Tree Spray	1B + 1A	F, O	
permethrin	Bayer Advanced Complete Dust, Ortho Bug-B-Gon Dust	3A	F, O, V	
trichlorfon	Bayer Advanced 24-Hour Grub Killer Plus	1B		L

F = fruit trees, L = lawns, O = ornamental trees and shrubs, V = vegetable gardens

farms, tree farms and golf courses. Table 4 lists botanical insecticides and biological control products for use by homeowners and professionals.

The chemical name, examples of the trade names and the Insecticide Resistance Action Committee (IRAC) mode of action group number are provided in each table. If multiple treatments are needed, we recommend rotating treatments with different modes of action to prevent or delay the development of resistance to individual insecticides. The tables also indicate the sites where individual insecticides can be used, and which Japanese beetle life stages are controlled.

Listing all available trade names for all insecticides is impractical because so many individual products are available. We recommend you bring this publication with you when purchasing insecticide products so you can be sure you are selecting a product with the recommended active ingredient to control the targeted beetle life stage, and the product is registered for use on the intended site. All of this information is listed on the product label.

As always, be sure to read, understand and follow all directions on the label. For applications to fruit trees and vegetable gardens, be sure to follow the preharvest interval listed on the product label.

Table 3. Insecticides for use by professional applicators in residential areas, nurseries, tree farms, sod farms and golf courses.

Active Ingredient	Example Trade Name(s)	IRAC Group	Adults	Grubs
acephate	Orthene T, T&O 97	1B	O	
bifenthrin	Onyx, Talstar-P	3A	L, O	
bifenthrin	*Onyx Pro	3A	GC, L, N, O, SF, TF	NS
bifenthrin	Talstar Nursery Granular	3A		NS
bifenthrin	*Brigade 2EC	3A	SF	
carbaryl	Sevin SL	1A	O, TF	GC, L
chlorpyrifos	*Nufos 4E	1B		SF
cyfluthrin	Decathlon 20 WP	3A	O, N	
deltamethrin	Deltagard T&O 5SC	3A	L, O	
deltamethrin	*Deltagard GC	3A	GC, L, N, O, SF	
dinotefuran	Safari 20SG	4A	N, NS, O, TF	
halofenozide	Mach 2 1.5G, Mach 2 2SC	18		GC, L, TF
imidacloprid	Marathon II	4A		N, NS, TF
imidacloprid	Merit 2.5G	4A	O	
imidacloprid	Merit 75WP	4A	O	L, SF
imidacloprid	Merit Tree Injection	4A	O, N, TF	
lambda-cyhalothrin	Scimitar CS	3A	L, O	
lambda-cyhalothrin	*Scimitar GC	3A	GC, L, N, O, SF	
permethrin	*Perm-UP 3.2EC	3A	N, O,	
thiamethoxam	Meridian 0.33G, Meridian 25WG	4A	O	GC, L, SF

* Restricted-use pesticide

GC = golf courses, L = lawns, N = nurseries, NS = nursery stock (containerized), O = ornamental trees and shrubs, SF = sod farms, TF = tree farms

Table 4. Botanical insecticides and biological control products for use by homeowners and professionals.

Active Ingredient	Example Trade Name(s)	IRAC Group	Adults	Grubs
azadirachtin	Aza-Direct	UN	F, O, V	
azadirachtin	Ecozin Plus 1.2% ME	UN	F, V	
pyrethrins + piperonyl butoxide	EverGreen EC 60-6	3A	F, O, V	
predatory nematodes	NemaSeek			GC, L

F = fruit trees, GC = golf courses, L = lawns, O = ornamental trees and shrubs, V = vegetable gardens

What to Do If You Find a Suspected Japanese Beetle Adult or Grub

Because Japanese beetle reproduction and establishment has not been confirmed in North Dakota, reporting all suspected Japanese beetle findings to NDSU Extension Entomology is extremely important.Take the following steps:

1. Collect the specimen(s) and place them in a liquid-tight vial of 70 percent rubbing alcohol.
2. Record the exact collection location, collection date and name of collector.
3. Record the host plant(s) on which the beetles were found or type of grass for grubs (for example, lawn, golf course, sod farm).
4. Count or estimate the total number of individual beetles that were observed.
5. You may provide photographs of the plant damage, but photographs of specimens are not a substitute for the specimens. Having physical specimens is very important.
6. Promptly notify NDSU Extension Entomology (janet.knodel@ndsu.edu and patrick.beauzay@ndsu.edu) and provide us with the specimens and collection data.

   Specimens and data should be sent to:

   If using U.S. Postal Service:

   Patrick Beauzay
   Dept. of Plant Pathology
   319 Walster Hall
   NDSU Dept. 7660
   P.O. Box 6050
   Fargo, ND 58108-6050

   If using courier service (UPS, FedEx, etc.)

   Patrick Beauzay
   Dept. of Plant Pathology
   306 Walster Hall
   Bolley Drive
   Fargo, ND 58102

Japanese beetle damage to rose (Clemson University - USDA Cooperative Extension Slide Series, www.Bugwood.org)

Selected References

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For more information on this and other topics, see www.ag.ndsu.edu

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