PEST ASSESSMENT: Japanese Beetle, *Popillia japonica* Newman, (Coleoptera: Scarabaeidae)

USDA-APHIS-PPQ-CPHST-PERAL/ NCSU

Section A: Species Information

Figure 1. Adult *Popillia japonica.* Photograph by Cyde Gorsuch, Clemson University - USDA Cooperative Extension Slide Series, www.invasive.org

Scientific name:
Popillia japonica

Order: Coleoptera

Family: Scarabaeidae

Common Name: Japanese beetle

Source: Fleming , 1972

D**escription:** (All descriptions are summarized from Fleming, 1972)
Eggs: Newly deposited eggs may be quite variable in size and shape: spheroids with a diameter of 1.5 mm, ellipsoids 1.5 mm long by 1.0 mm wide, or nearly cylindrical. Color may range from translucent to creamy white and the external surface is marked with hexagonal areas. The eggs enlarge to nearly double the initial size and become more spherical as the embryo develops within the chorion.

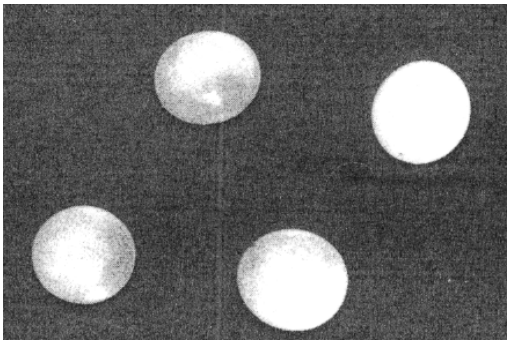


Figure 2. *P. japonica* eggs (from Fleming, 1972)

Larvae: Upon eclosion, the first larval instar is completely white, 1.5 mm in length with biting mouthparts, three pair of thoracic legs and ten abdominal segments. The larval body is typically found in the shape of a C, which is referred to as scarabaeiform (Figure 3). Within a few hours after eclosion, the head and spiracles of the larvae sclerotize to a light yellow brown color. After initiation of feeding, a grayish to black color may appear in the posterior region of the abdomen. The body of the larvae is covered with a scattering of long brown hair and interspersed short blunt spines. The ventral side of the tenth abdominal segment bears two medial rows of six-seven spines in a characteristic V shape (Figure 3). The V shape is unique to *P. japonica* and may be used to distinguish it from other species of scarab larvae. The first larval instar is distinguishable from the subsequent instars by presence of a rigidly pointed process on each side of the metathoracic scutellum and lack of a concave respiratory plate surrounding a bulla with a curved spiracle slit. The second and third instar larvae can be separated by head capsule size, the head capsule size of the second larval instar is 1.9 mm wide and 1.2 mm long and the third instar is 3.1 mm wide and 2.1 mm long.

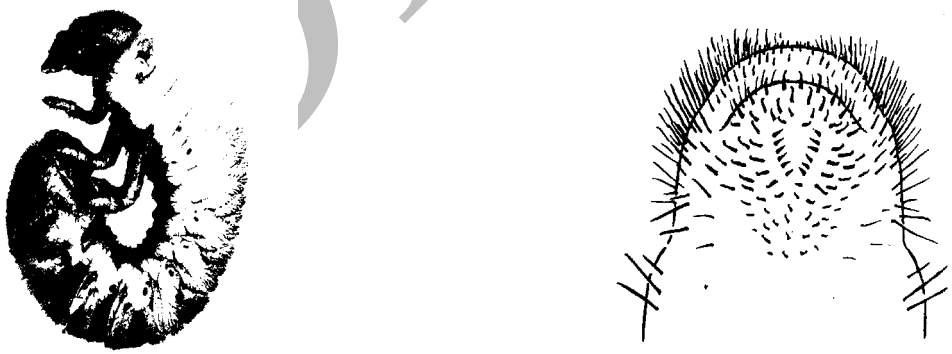


Figure 3. Mature third instar larvae of *P. japonica* (left) and arrangement of hair and spines on underside of last body segment with diagnostic V-shaped arrangement of spines (right) (From Fleming 1972).

Prepupa: The larva is mature, but feeding ceases, excrement is evacuated and activity is reduced as internal changes occur.

Pupae: The pupae are on average 14 mm in length and 7 mm wide and exarate in form. Pupae resemble the adult, but wings, legs and antennae are held close to the body and functionless. The color changes from a cream color to tan and eventually the metallic green observed in the adult. Male and female pupae are separated from each other by a three lobe eruption covering the developing genitalia on the posterior ventral abdominal segments of the male.

Adult: The adult beetle is brightly colored metallic green and coppery bronze, oval in shape, and varying in length from 8-11 mm in length and 5 to 7 mm wide. The female of the species is typically larger than the male. Along each lateral edge of the elytra there are five spots of white hair present as well as two dorsal spots of white hair on of the last abdominal segment. Male and female beetles are differentiated from each other by the shape of the tibia and tarsus on the foreleg. The male tibial spur is more sharply pointed and the tarsi are shorter and stouter than those of the female (Figure 4).

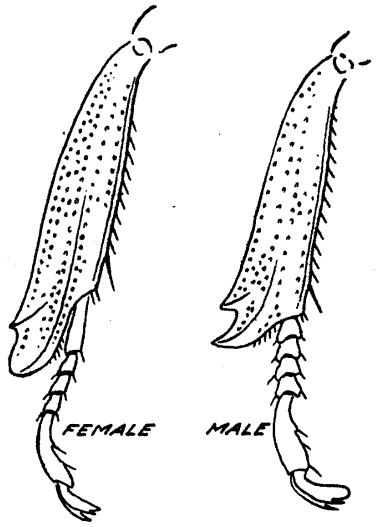


Figure 4. Fore tibiae and tarsi differentiation of female and male *P. japonica*.

Life History: (Summarized from Fleming, 1972 and Regniere et al. 1981a,b,c,d)

Popillia japonica typically completes one generation per year, with occasionally two years being required to complete single generational development in the northern regions of infestation. *Popillia japonica* overwinters in the soil within earthen cells as second or third instar larvae at depths ranging from 10-30 cm, with the greater depth occurring at colder temperatures. As soil temperatures increase in the spring, larvae move up in the soil strata and feed on plant roots. Larvae then cease feeding and undergo pre-pupal and pupal stages of development.

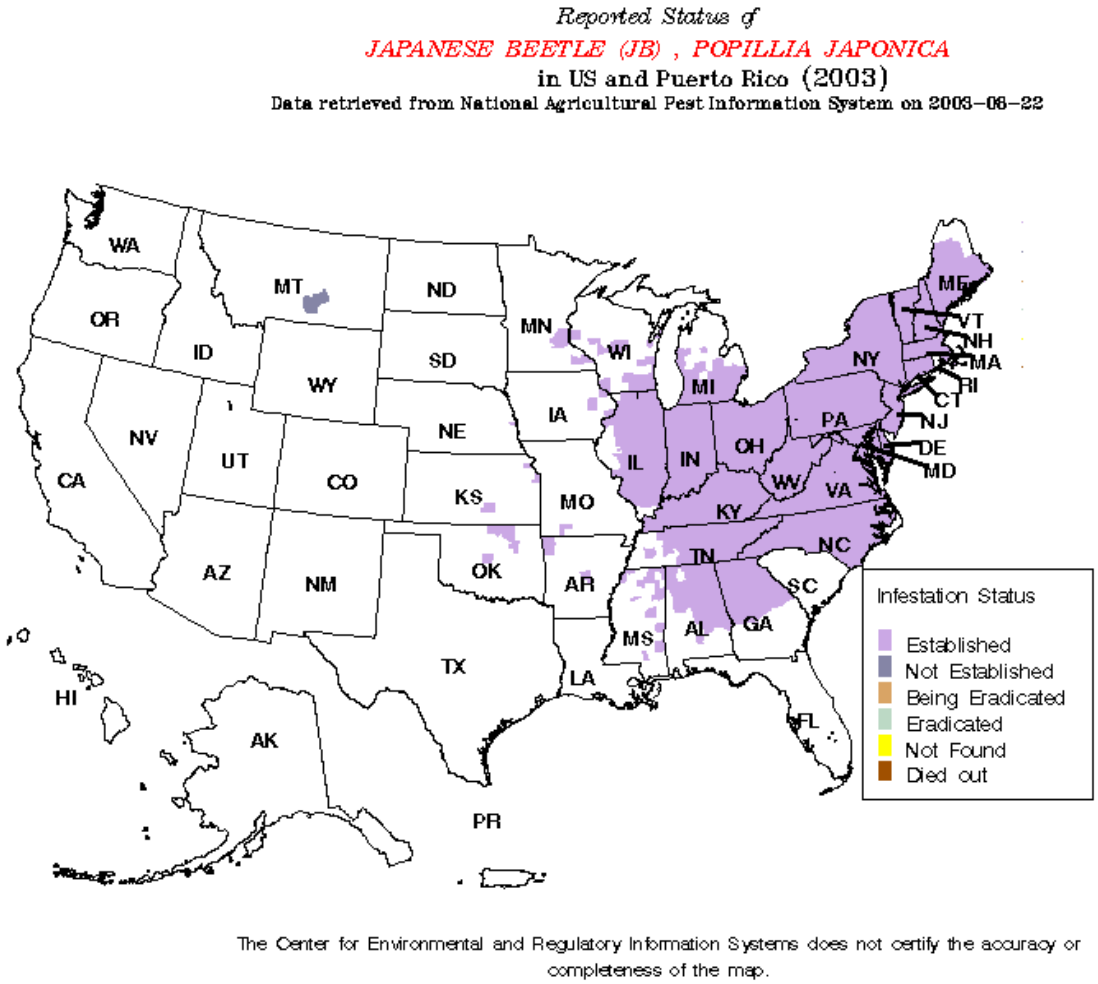
Adult beetles shed their pupal skin underground and emerge within 2-14 days, depending on temperature and environmental conditions. Adult beetles are polyphagous and have been reported as feeding on over 435 different species of plants in 95 different families, although moderate to severe damage only occurs on 106 (24%) of these species. Adults often aggregate in areas to feed and mate and have been described as gregarious. Adult *P. japonica* feeding causes

skeletonization of the plant leaves and may result in complete defoliation. Mating occurs multiple times during the 30-45 day lifespan of the typical adult beetle, with newly emerged virgin females being highly attractive to males. After fertilization, female beetles burrow 5-10 cm into the soil and deposit a single egg in a depression made by her ovipositor. Several eggs may be laid within individual depressions in close proximity to each other. The female beetle may remain underground for a few days before emerging to mate again and repeat the oviposition process, laying 40-60 eggs over the course of her lifetime.

Larvae emerge from the eggs and feed on the roots of various hosts. *Popillia japonica* feeding on turf grass, such as commercial and residential lawns and golf courses, may result in severe economic loss that is often unrecognized until the plants are significantly damaged.

Some of the plant genera more severely damaged by adult *P. japonica* feeding are *Acer* (maple), *Malus* (Apple), *Prunus* (cherry, plum, peach), *Rosa* (rose) and *Vitus* (grape).

Figure 5. Geographic distribution and infestation status of *Popillia japonica*



The Center for Environmental and Regulatory Information Systems does not certify the accuracy or completeness of the map.

Prediction Model:

A generic insect degree day model was used to predict the emergence and development of *P. japonica* for a single generation in the United States with temperature accumulations above the low developmental threshold as the main weather factor controlling the pest insects' biology. The template is based on the time of development for a generation of *P. japonica* with degree days accumulated above the lower developmental threshold of 10 C for all stages and individual stage degree day (DD) requirements as determined from values by Ludwig, (1928) and further examined by Regniere (1981a). The upper developmental temperature threshold for *P. japonica* was established at 34 C based on Ludwig (1928) and Regniere (1981a). In the literature there has been various developmental temperature thresholds reported for the various stages of this widely studied insect. *Popillia japonica* overwinters as second or third instar larvae, and 10 C is the low threshold reported, 10 C was selected as the degree day base developmental temperature. In the template, the oviposition section does not represent the length of oviposition time by the adult, but rather the number of degree days required for an egg to develop and hatch following deposition.

Results.

The risk probability maps generated for *P. japonica* (Figure 6) are for a several time periods, May 22-31, June 1-7, 8-14 and 15-21, which were selected based upon anecdotal references of adult emergence and to depict emergence progression. The model parameters for the overwintering adult stage were examined by individual year in a 30 year historical national weather database. The data is interpreted as the number of times the model parameters (accumulated degree days (DD) between temperature thresholds) occur within the selected timeframe (i.e. if the designated DD accumulations for a specific location occur 10 years out of 30 than there is a 30% probability of occurrence or 3 out of 10 years). From the generated maps in figure 6, there is a progression in adult emergence which begins in late May in the southern areas of infestation and a progression northward as time passes. There were no crop overlays generated for *P. japonica* as it is primarily a pest of ornamentals and highly phytophagous, but maps may be generated in the future and actual emergence data compared to model predictions.

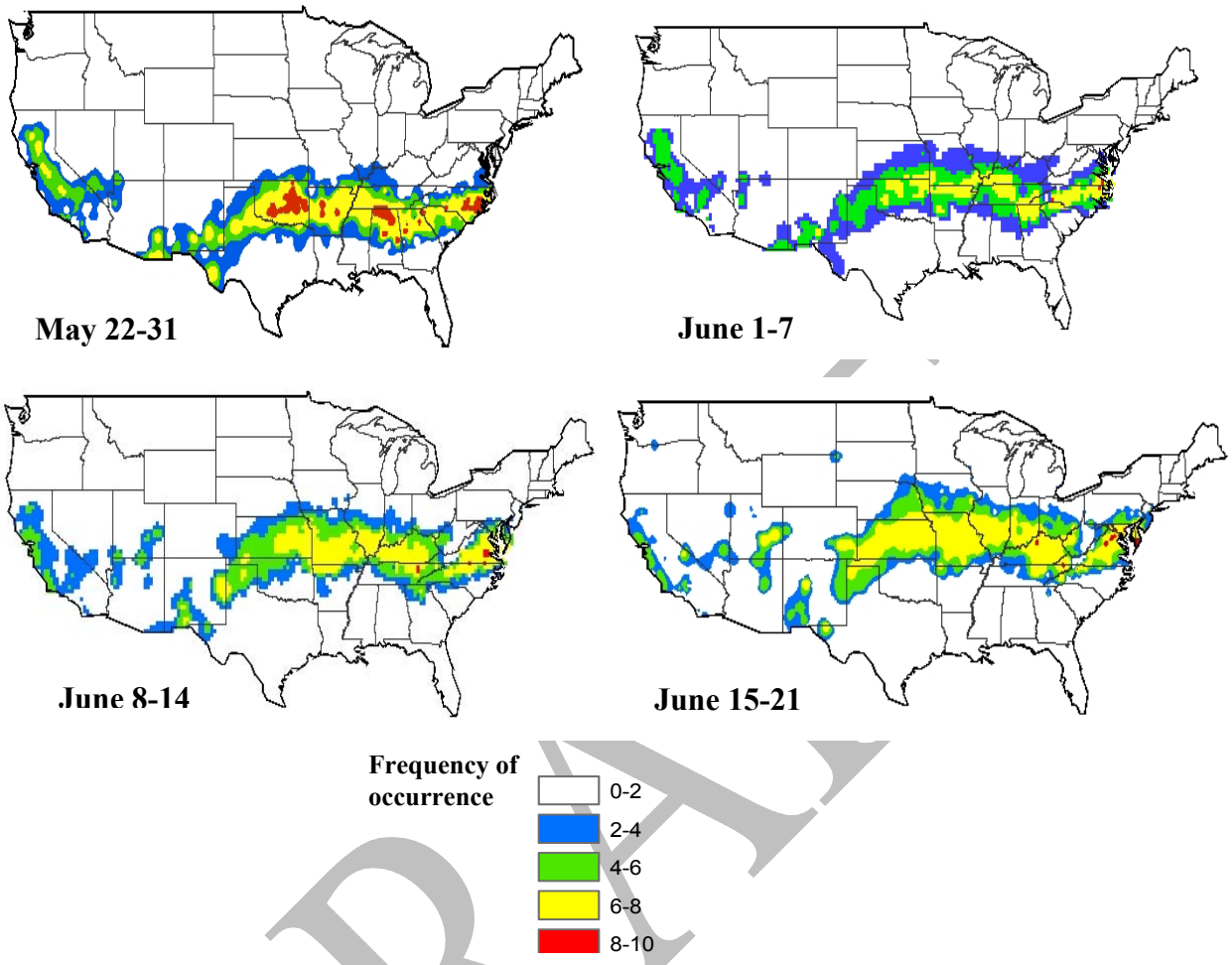


Figure 6. Probability maps of adult *P. japonica* emergence represented by the frequency of occurrence out of 10 years. Maps generated from 30-years climactic data. Dates selected to demonstrate shift of probability over time and geography.

Authors:
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Section D:
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Japanese Beetle

	Stage	DD in stage	First entry	second entry
Overwintering stage	3rd instar larvae	400	0	400
	pupae	124	401	525
Lower Threshold10	adult	117	526	643
Upper Threshold34	egg	140	644	784
	1st instar larvae	222	785	1007
	2nd instar larvae	419	1008	1427
	3rd instar larvae	720	1428	