Ecofarming (e-Magazine)

Agriculture

Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

Bacillus popilliae

A bacteria causing 'milky disease' in Japanese beetle

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Received: July, 2025; Accepted: August, 2025; Published: October, 2025

Abstract

The rod-shaped, soil-dwelling bacteria *Paenibacillus popilliae* (formerly known as *Bacillus popilliae*) is Gram-positive. It causes the white grubs of Japanese beetles to get an illness known as milky spore. It is a pathogen of various scarabaeid beetles. Bacillus popilliae represents a unique category among bacteria. It is gram-variable, facultatively anaerobic, catalaseless, insecticidal, and it forms endospores along with parasporal crystals.

Keywords: *Paenibacillus popilliae* , Japanese beetles, milky disease, *Popillia japonica*, Biocontrol

Introduction

Taxonomical classification

Paenibacillus popilliae

Scientific classification

Domain: Bacteria

Phylum: Bacillota

Class: Bacilli

Order: Bacillales

Family: *Paenibacillaceae*

Genus: Paenibacillus

Species: *P. popilliae*

The rod-shaped, soil-dwelling bacteria *Paenibacillus popilliae* (formerly known as *Bacillus popilliae*) is Gram-positive. It causes the white grubs of Japanese beetles to get an illness known as milky spore.

The obligatory pathogens *Paenibacillus popilliae* and *Paenibacillus lentimorbus* infect the larvae of the subfamilies *Melolonthinae, Rutelinae, Aphodinae* and *Dynastinae* of scarabs and produce "milky illness" (Klein, 1992; Garczynski and Siegel, 2007; Jurat-Fuentes and Jackson, 2012). The phrase "milky disease" refers to the afflicted larvae's characteristic opaque white hue, which is brought on by an overgrowth of sporulating bacteria in the larval hemolymph (blood). These bacterial strains are extremely specialised, with little to no cross-infectivity to species other than the one from which they were obtained. Only the strain that affects *P. japonica* has been commercialised and has been in use in the US for more than 60 years. The substance must be applied via an inoculative strategy, depending on recycling in infected larvae to spread the disease because there is no efficient mass production system. Although spores can survive in the soil for several years, the use of *P. popilliae* has been limited because to its limited availability and patchy performance and establishment (Klein, 1992; Redmond and Potter, 1995). Commercially available strains that infect grubs from species other than *P. japonica* have not yet been created. The application of *P. popilliae* will remain extremely constrained until efficient *in vitro* synthesis or more virulent strains can be created. This bacterium is recognised as the country's first microbial biocontrol agent to be registered formally.

Fig . Healthy beetle larva (left); larva infected with *B. popilliae* (right).

PHOTO: Michael Klein, USDA, ARS, Horticultural Insects Research Lab, OARDC,

Target Host

These are bacteria that live in soil and are only employed to wreak havoc on *Popillia japonica* (Coleoptera: *Scarabaeidae*), also known as the Japanese beetle, by generating milky disease. By consuming plant tissues, these beetles seriously damage a wide variety of commercially significant crops.

In the Northeastern United States, mature Japanese beetles pupate in July and consume the blossoms and leaves of shrubs and garden plants. The beetles reproduce at this adult stage, and in late July or early August, the females bury their eggs in the ground. Soon after, the eggs hatch into larvae or grubs they feed on the roots of grass and other plants. The grubs burrow deeper into the dirt as the temperature drops and winter draws near, and as they overwinter, their appetites decrease.

When the grubs are feeding near the surface in August, they are more susceptible to milky spore invasion. Also, this is the best time to inoculate turf or apply milky spore to the soil to boost milky spore levels (there are product specific guidelines that should be followed for milky spore application).

Grubs normally consume spores in the soil as part of their routine of eating roots. The host's consumption of the spore triggers the grub's internal bacterial population to multiply. The grub will finally pass away between 7–21 days, and as it decays, billions of fresh spores are discharged into the soil.

Milky spore, like other bacteria, is highly resilient to dry circumstances but suffers in temperatures of Zone 5 and below. It is not detrimental to beneficial insects, birds, bees, pets, people, or other animals.

Mode of Action

These microbes are found in soil naturally and can be employed as biocontrol agents. The soil is treated with the antibacterial solution. The bacterial spores are consumed by grubs that are eating the roots of grass or other plants, which starts the disease. Chitin, a structural polysaccharide found in insect exoskeletons and gut lining, is hydrolysed by the chitinase enzyme it generates, which kills the insect. The spores germinate in the midgut, where vegetative cells infiltrate the midgut epithelium and begin to develop and multiply before eventually invading the hemocoel (body cavity). The bacteria enter the blood after crossing the midgut's basement membrane, colonise it over a period of weeks, and sporulate until they reach populations of 100,000,000 cells ml. When larvae consume enough spores at an early stage of development,

the illness is lethal. In essence, dead larvae form spore foci that can spread infection for up to 30 years. masses of vegetative bacteria that can pierce gut walls and enter haemolymph to kill larvae germinate in the gut of the host. The spores enter the soil through the breakdown of dead larvae and are resistant to unfavourable environmental conditions.

Paenibacillus popilliae as a biocontrol agent

The fact that adequate conditions for *B. popilliae* and its close cousins' growth and mass production *in vitro* have not been developed despite decades of research is one of its disadvantages. This has hampered *B. popilliae* research and extensive commercial development. The technical component (i.e., spores) that forms the foundation of commercial formulations is created in living organisms, as has been the case for many years. The procedure is defined by (Koppenhöfer *et al.* 2012). and was extensively documented by Fleming in 1968. Healthy larvae were gathered from the field and injected with 33 l of sterile spore solution at a dose of roughly 1107 cells/larva. After that, the larvae were placed in soil kept at 30°C for up to 20 days until the majority of the larvae displayed signs of infection. After being kept in cool water, the infected larvae were minced with a meat grinder and combined with talc and calcium carbonate to create a powder that contained 1108 spores/g. According to Fleming (1968), the United States Japanese Beetle Laboratory generated more than 80 tonnes of standardised spore powder for use in controlling the United States between 1939 and 1953. Spore powder was applied at 160,000 sites all over the affected area to start infections, until natural infections became common and the program was cancelled this was considered as a colonization approach. According to Fleming's data, the programme collected, infected, and processed around 5 million Japanese beetle larvae. Several attempts at artificially producing *P. popilliae* were made in an effort to get around the tedious production procedure, but none of them were effective enough to be used for commercial production (Stahley and Klein, 1992). Due to the serious issues caused by scarab larvae, such as damage to turf grass by *Popillia japonica's* larvae, *B. popilliae* still has a small but steady market in the United States. Milky spore powder is still produced in vivo by a company producing "Milky Spore" for the home lawn and organics markets. The Japanese beetle was heavily controlled using *Paenibacillus (Bacillus) popilliae*, the first bacterium to be registered in the United States (*Popillia japonica*; Klein, 1992). The bacterium, which causes milky disease in *P. japonica* larvae, was created by a beetle that was at the time spreading throughout the eastern United States.

For the control of Japanese beetles, chafers, as well as some May and June beetles, the insecticide **Japademic** (=*Paenibacillus popilliae*) is based on the bacteria *Bacillus popilliae*. produced by Fairfax Biological Laboratories, Inc. in the United States.

Conclusion

Since the use of chemical pesticides is very harmful to us and the environment and it increases farmers expenses. Biopesticides are a great alternative to chemical pesticides as they does not cause any harmful effects to us or the environment. *Bacillus popilliae* is a type of bacteria that is responsible for causing 'milky disease' in Japanese beetles. This disease is characterized by the formation of a milky-white fluid in the beetle's body, which eventually leads to its death. *Bacillus popilliae* is considered an effective biological control agent for controlling the population of Japanese beetles, as it is specific to this insect and does not harm other organisms. The use of this bacteria as a biopesticide has gained attention in recent years due to its potential as an environmentally friendly alternative to chemical pesticides. Further research and development in this area could lead to the widespread use of Bacillus popilliae as a safe and effective method for managing pest populations in agriculture and horticulture. But they does have some drawbacks like mass production for commercial purpose is not easy

similar to above discussed bacteria *Paenibacillus* (*Bacillus*) *popilliae* it is a great control for scarab larvae but it won't be economical to use is as a control measure unless and until its mass production.

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