International Journal of Entomology Research
www.entomologyjournals.com
E-ISSN: 2455-4758
Received: 11-09-2026, Accepted: 11-10-2026, Published: 26-10-2026
Volume 11, Issue 4, 2026, Page No. 161-164

Historical overview on entomological warfare

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DOI: https://doi.org/10.66856/ijer.2026.11.4.11381

Abstract
Entomological warfare (EW) is the use of insects as weapons to disrupt supply lines, destroy crops, or damage populations. There is a record of limited validated use of EW against China in WW2 but the concept is ancient with several recorded instances. EW can be used in three ways: insects as direct weapons, insects as crop destroyers and insects as disease vectors. Other historical examples include plague-infested fleas during the Black Death in the 14th century and ancient warfare where pots were filled with scorpions. The use of insects as biological warfare agents is generally banned in modern international law but countries such as Japan, Germany and the U.S. have experimented or adopted programs for the use of insects as biological agents during warfare. The potential of EW has grown with advances in technology. Genetically engineered insects for military applications have been discussed.

Keywords: Entomology, biological, warfare, crop, pest

Introduction
Entomological warfare (EW) is a form of biological warfare that involves the use of insects to disrupt supply lines by damaging crops or to directly attack enemy combatants and civilian populations. Several programs have tried to carry out this methodology, but there has been limited application of entomological warfare against military or civilian targets, Japan being the only state known to have verifiably applied the method against another state, the Chinese during World War 2. EW, in contrast, was more common in antiquity to ward off sieges or to inflict economic damage to states. (Nie, 2020) [8]. During the Cold War and World War 2 many states, including the Soviet Union, the United States, Germany and Canada conducted research into EW. There have also been suggestions it could be the work of non-state actors, in an act of bio-terrorism. The use of insects as delivery systems for agents or toxins for hostile purposes is prohibited by international law under the Biological and Toxic Weapons Convention of 1972 (Robins, 2025). The use of insects to deliver agents or toxins for hostile purposes is considered to be illegal under the Biological and Toxic Weapons Convention of 1972. Humans have waged entomological warfare — the use of insects and other arthropods as part of wartime tactics — in myriad ways for thousands of years. Entomological warfare has a long history and is a subject of interest with many examples of interest from both an entomological and sociological standpoint.

Entomological warfare (EW) has appeared in human history in three basic forms
1. Insects used directly as weapons.
2. Insect pests which destroy the crops.
3. Insects used as vectors to spread disease.

History
Entomological warfare is not a new concept; EW has been studied by historians and writers in connection with multiple historic events (Khalil *et al.*, 2025) [6]. A 14th-century plague epidemic in Asia Minor which became known as the Black Death (carried by fleas) is an event that has been looked upon by historians as a possible early incident of entomological warfare. The plague might have spread across Europe due to a biological attack on the Crimean city of Kaffa. King Barsamia, during the Second Parthian War, defended the ancient Middle Eastern city of Hatra from the Romans with pots filled with scorpions and hurled at the enemy (Tucker,2009) [13]. These literal bug bombs may have even included rove beetles from the genus Paederus. These tiny rove beetles contain the compound pederin in their hemolymph. Pederin causes dermatitis and blisters on contact with skin, which is what would have happened when panicked warriors began smashing the beetles that had been thrown at them. King Mithridates VI of Pontus also used arthropods in his wartime manoeuvres but preferred those of the hymenopteran persuasion. In the Third Mithridatic War, Mithridates ordered honey bees foraging on rhododendron to be used to place honey laced with grayanotoxin along roads for pursuing Roman invaders. When warriors consumed this honey as part of their pillaged loot, they suffered intense sickness and hallucinations, which gave it the name “mad honey.” The incapacitated Romans were easy prey for Mithridates’ army. Mithridates also sent hornets and bees into the tunnels dug by the sappers under the battlefields. Clearly applied entomology has a very long, if brutal history. According to Jeffrey Lockwood, author of Six-Legged Soldiers (a book about EW), the first case of entomological warfare was likely the use of bees by early humans. The bees or their nests were thrown into caves to drive the enemy out into the open. Lockwood suggests the Ark of the Covenant was lethal when opened because it contained fleas. During the American Civil War, the Confederacy charged the Union with the deliberate introduction of the harlequin bug into the South. The charges were never proved and recent research indicates that the insect more likely arrived by other means. It wasn't until

World War II that the world saw widespread entomological warfare. And the only confirmed cases of BW or EW during the war were the Japanese attacks in China. Other nations started their own EW programs during and after the war.

Some examples of entomological warfare

1. Second World War

France: France, like Germany, is known to have pursued entomological warfare programs during World War II, and France, like Germany, proposed the Colorado potato beetle, which targeted the enemy's food sources, as an asset during the war. By 1939, bioweapons specialists in France had recommended the use of the beetle against German crops (Whitby, 2002) [15].

Germany: Germany is known to have conducted entomological warfare programs during World War II. The country pursued mass production and dispersion of the Colorado potato beetle (Leptinotarsa *decemlineata*), targeted at the enemy 's food sources. The beetle was first found in Germany as an invasive species from North America in 1914. There is no evidence to suggest that the beetle was ever used as a weapon by Germany or any other nation during the war. In any event, the Germans had developed plans to drop the beetles on English crops. Germany tested its weaponization program for the Colorado potato beetles south of Frankfurt by releasing 54,000 of the beetles. An infestation of Colorado potato beetles was observed in Germany in 1944. The source of the infestation is unknown; speculation provides three alternative theories as its source. One possibility is that it was an Allied attack, an entomological attack; another is that it was the result of the German testing, and still another more likely explanation is that it was merely a natural occurrence. (Hajek *et al.*, 1990) Beyond these historical efforts, entomological warfare encompasses the use of arthropods as direct pests against agricultural resources, or as sophisticated biological vectors capable of transmitting debilitating pathogens to both animal and human populations (Chaudhry *et al*., 2018).

Canada: Canada was the first of the Allied Powers to pioneer warfare by vector. (Pillai *et al*. 2023) [10]. Once Japan was interested in developing the plague flea as a weapon, Canada and the United States quickly followed suit. Dr. G.B. Reed, chief of Kingston's Queen's University's Defence Research Laboratory, worked closely with the United States and focused his research during World War II on mosquito vectors, biting flies and plague-infected fleas. Much of the research was shared with or done in concert with the United States. Canada had the most advanced bio-weapons program in the world during the war, ahead of the British and the Americans. The Canadians tended to work in areas that their allies ignored, and entomological warfare was one such area. The Canadians worked closely with both the U.S. and British programs as they developed. The Canadian BW work would continue well after the war, including entomological research.

Japan: Japan waged massive entomological warfare on China during World War II. The Japanese biological warfare unit, Unit 731, headed by Lt. General Shirō Ishii, used infected fleas with the plague and flies carrying cholera to infect the population. The Japanese Yagi bombs developed at Pingfan had two compartments, one containing housefly and the other containing a bacterial slurry that coated the houseflies prior to release. The Japanese military spread them from low flying aeroplanes. They sprayed the fleas from them and dropped the Yagi bombs filled with a mixture of insects and disease. Localised and deadly epidemics followed, and nearly 500,000 Chinese died of disease. In 2002, a group of international historians declared that Japanese entomological warfare in China caused the death of 440,000. (Wiedenmann & Fisher, 2021) [16].

Great Britain: A British scientist, J.B.S. Haldane, observed that both Britain and Germany were susceptible to an entomological attack by the Colorado potato beetle. The US sent 15,000 Colorado potato beetles to Britain in 1942 to study as a weapon. (Whitby 2002) [15].

2. The Cold War

Soviet Union: The Soviet Union had an entomological warfare program that was a major part of an anti-crop and anti-animal BW program, and it studied, developed and tested it. The Soviets devised techniques of using insects to transmit animal pathogens such as foot and mouth disease, which they used ticks to transmit; avian ticks to transmit Chlamydophila psittaci to chickens (Pillai *et al.*, 2023) (Domaradskij & Orent, 2006) [2]. The Soviets also asserted they had built an automated mass insect-breeding plant that could turn out millions of parasitic insects each day.

United States of America: The United States did some serious research into the potential of entomological warfare during the Cold War. The U.S. military had designed an entomological warfare facility that would produce 100 million yellow fever infected mosquitoes per month. In a report entitled "Entomological Warfare Target Analysis", the U.S. Army identified sites within the Soviet Union that were vulnerable to the United States using entomological vectors. The military even tested the capacity of mosquito biting by dropping uninfected mosquitoes over U.S. cities. In the 1950s, the United States conducted a series of field tests with entomological weapons. (Pal *et al.*, 2017) [9].

Operation Big Itch: Operation Big Itch was a series of tests held at Dugway Proving Ground, Utah, in September 1954. Tests were conducted on the coverage patterns and survivability of the tropical rat flea (Xenopsylla cheopis) as applied to biological warfare in terms of a disease vector. These trials were conducted with fleas free of any biological agent. Fleas were loaded into two types of munitions and dropped from the air. The E14 bomb and E23 bomb could be combined to form the E86 cluster bomb and E77 bomb respectively. They would drop the cluster bombs at 2,000 or 1,000 feet, then the bomblets would drop via parachute, disseminating their vector. The E14 was designed to hold 100,000 fleas and the E23 was to hold 200,000 fleas. The E23 had failed in more than half of the preliminary Big Itch tests. The E23s fell apart in a test and fleas escaped inside the plane and bit the pilot, bombardier and an observer. So, the rest of the Big Itch tests were done with just the smaller capacity E14.

Operation Big Buzz: Operation Big Buzz was conducted in May 1955 in Georgia, USA. The operation was a field test to determine the feasibility of producing, storing, loading into munitions and dispersing from aircraft the yellow fever

mosquito (although these were not infected for the test) (Aedes aegypti). Another goal of the operation was to see if the mosquitoes would survive long enough to fly off and look for blood on the ground. Some 330,000 uninfected mosquitoes were released from E14 bombs from aircraft and from the ground. Approximately 1 million female mosquitoes were bred for testing purposes. The remaining mosquitoes were used for munitions loading and storage tests. Those air-dropped mosquitoes were released from aeroplanes 300 feet (91 m) above the ground, dispersing on their own and with the wind.

Operation Magic Sword: Operation Magic Sword was a U.S. military operation in 1965. Its aim was to assess the effectiveness of the use of mosquito vectors for biological agents in the sea. The experiment was conducted off the southeast coast of the United States with yellow fever mosquitoes to test how they bite after being released into the ocean.

Operation Dropkick: The United States Between April and November 1956. Operation Drop Kick was conducted by Army Chemical Corps to test the feasibility of mosquitoes as a vector for distributing an entomological warfare agent in various ways. The Corps released non-infected female mosquitoes into a cooperative residential area of Savanna, Georgia and estimated how many mosquitoes entered houses and bit people. Within a day many people were bitten by the mosquitoes. In 1958 the Corps let loose 600,000 mosquitoes in Avon Park, Florida.

May Day Operation: Operation May Day was a series of EW tests carried out between April and November 1956. The tests were designed to give some information on the dispersal of the yellow fever mosquito in an urban environment. The Corps released the mosquitoes from ground level in Savanna, Georgia, then recovered them with traps baited with dry ice. U.S. operation, partially declassified, was described in a Army report, 1981.

Insects as Pests of Crops

Insect attack on enemy crops is an odious act of EW, one that many countries have accused each other of, but is also rarely proven (Frischknecht, 2003) [3]. In 1944 Germany was accused of smuggling Colorado potato beetles into Britain to ravage crops. After the Vietnam War, North Korea accused the United States of spraying insects on its agriculture (although any loss of plants may actually have been caused by the defoliant Agent Orange). And Cuba said in 1997 that the U.S. dropped thrips on the island from the air during the Cold War. It's almost impossible to verify if these claims were true but they did certainly do their job in getting one country's complaints against another onto the world stage. Modern EW such as use of insects to destroy crops would be outlawed under the Biological Weapons Convention of the Geneva Conventions. Of course, an individual country can ignore these conventions at any time and not all countries subscribe to them in the first place.

Insects as Disease Carriers

Mosquitos and yellow fever. Lice and typhus. Fleas and plague. Such insects are perhaps best known as carriers of crippling diseases. Whether by accident or by design (as in catapulting plague-ridden corpses over city walls), insect-borne diseases have won battles and wars from Napoleon's conquests to the American Civil War. Many countries, including the United States, have studied insects and their associated diseases as biological weapons, and the U.S. has tested insect-based tactics on American citizens, including in Operations Drop Kick, Big Buzz, and Big Itch.

Insect weaponization

Operation sting & flung

The advent of machines that could fire insect-heavy payloads was a great advance in military pain delivery. The catapault did for the humble rock what the catapult did for bees — and tipped the balance of entomological power in favour of the attacking forces. European history is full of stories about beehives and wasp nests being used as warheads, even on the high seas as a very effective way to clear the decks of an enemy ship. Hive-heaving reached its high point in the 14th century with the invention of the entomological forerunner of the Gatling gun: a windmill-like machine that shot straw hives from the tips of the fast-spinning arms. But attacking forces weren't the only ones using stinging insects. European nobles saw that their bees were ready to make honey or havoc as occasion demanded. Mediaeval castles often had recesses in their innermost walls to house the six-legged troops, known as bee boles. Historical precedent has been observed in the use of natural swarms or found insects, while modern entomological warfare has evolved into a sophisticated field that intersects with synthetic biology and swarm robotics (Robin, 2025).

Eaten Alive (Slowly)

The 19th-century Emir of Bukhara (modern-dayUzbekistan), Nasrullah Bahadur-Khan, was known for his sadism—and perhaps most famous in history for what the locals called the Black Well. Western historians say the hole was 21 feet deep and covered with an iron grate and could be entered only by means of a rope. The Emir filled what is now called the "Bug Pit" with insects so that his victims would suffer endless torture. The torment was added to by the assassin bugs, the filthiest of the ruler's six-legged minions, and by their eight-legged cousins, the sheep ticks. They are carnivorous insects, about an inch long, with stout, curved beaks for piercing their prey, which is mostly other insects. But they'd eat people before they starved The bite of these insects has been likened to being stabbed with a hot needle, and the digestive enzymes they inject to liquefy the tissues of their prey cause festering sores in human flesh (Walker *et al.*, 2016) [14]. In addition, the transition from "found" weapons of insects to the mass production of vectors on an industrial scale, for example, the Japanese programs in World War II using plague-infected fleas, also demonstrates the changing strategic landscape of entomological warfare (Lockwood, 2011) [7].

Inspiration from insects

More recently our ever-adaptable insects have assumed a new role in warfare, one of bioinspiration rather than weaponry. Inspired by the cuticle of the ironclad beetle, an alloy that can recover its initial shape could be used for military vehicles (Katiyar *et al.*, 2021) [5]. A British engineering company is developing a defence surveillance drone called the Skeeter, based on the flight characteristics of dragonflies. The RoboBee is a small flying robot, with insect-like mechanics that could be used for covert

surveillance as well. These are just a few of the way's insects continue to inspire innovation, and entomology certainly has a bright future there is so much more to learn from and about insects. (Sharma *et al.*, 2023)

Conclusion

The 1972 Biological and Toxic Weapons Convention (BWC) does not include reference to insect vectors. Article 1 prohibits weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict. US intelligence officials have suggested insects could be genetically engineered via technologies to create GMO "Killer mosquitoes" or plagues that wipe out staple crops. Using insects as biological weapons is a very effective type of warfare. They can easily be used to spread disease among the enemy, and to destroy enemy crops and animals. There have to be checks and balances to stop biological weapons going into the hands of terrorists and being used to spread terrorism.

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