Chapter 11

Biological Control of Aquatic Weeds Using Insects

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ABSTRACT:- Aquatic weeds like *Eichhornia crassipes, Salvinia* spp., *Pistia stratiotes, Hydrilla verticillata,* and *Alternanthera philoxeroides* are one the most severe intruders of freshwater ecosystems worldwide. They form thick mats which block sunlight, reduces dissolved oxygen, degrade water quality, and disturb fisheries, navigation, irrigation systems, and local livelihoods. Conventional control methods like mechanical control and chemical control using herbicides are often costly, environmentally risky, and unsustainable in the long run. As an alternative, scientists have successfully explored the use of aquatic insects as biological control agents to suppress these invasive plants in natural waters.

Keywords- Tropical, urbanization, habitat fragmentation, dominance.

INTRODUCTION

Aquatic weeds are one of the major threats to the freshwater ecosystems across the globe. Most of these are invasive plants and proliferate rapidly in water surface like lakes, rivers, reservoirs, irrigation canals as well as wetlands, forming thick mats that disrupt natural ecological processes. Major aquatic weeds like *Eichhornia crassipes*, *Salvinia molesta*, *Pistia stratiotes, Hydrilla verticillata,* and *Alternanthera philoxeroides*

Citation: Mukherjee, P., Shekhar, A. & Singha, M. (2026). Biological Control of Aquatic Weeds Using Insects. *Economic Insects of Jharkhand, Vol. 1, ISBN: 978-81-982354-3-5. pp. 153-160. https://10.5281/zenodo.20176158*
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are broadly known for their aggressive growth and high reproductive capacity. Their spread has been due to enrichment of nutrient, climate change, and increased human interference in aquatic environments.

The increase of aquatic weeds leads to significant ecological as well as socio-economic impacts. Intense infestations reduce light penetration and dissolved oxygen levels, leading to the reduction of native aquatic flora and fauna. Aquatic weeds also hinder water flow, interfere with navigation and fishing activities, clog irrigation and drainage systems, and create breeding grounds for disease-vector pathogens. Consequently, invasion of aquatic weed poses serious challenges to management of water resources, conservation of biodiversity, and livelihoods associated with freshwater systems.

Conventional methods used for aquatic weed management include mechanical removal and chemical herbicide application. While these approaches can provide rapid short-term control, they are often expensive, labour-intensive, and environmentally unsustainable. Mechanical removal frequently leads to rapid re-infestation if not continuously maintained, whereas chemical herbicides may cause non-target damage, contaminate water bodies, and disrupt aquatic food webs. These limitations have prompted the search for environmentally friendly and sustainable alternatives.

Biological control, particularly through the use of aquatic insects, has emerged as a promising approach for managing invasive aquatic weeds. Many insect species exhibit high host specificity and feed exclusively on particular aquatic plants, hence reducing weed biomass and suppressing growth without causing widespread ecological harm. Many insect agents, including *Neochetina* spp. against water hyacinth, *Cyrtobagous salviniae* against giant salvinia, *Agasicles hygrophila* against alligator weed, and *Hydrellia pakistanae* against hydrilla, have been successfully introduced and studied in different parts of the world. These insects weaken plants through mining of leaf, stem boring, sucking of sap, or defoliation, often resulting in long-term suppression of weed populations.

In spite successful documentation, the effectiveness of aquatic insect-based biological control varies in different ecosystems due to changing environmental factors, management practices, and interactions with other control methods. Considering the said facts, the current studies is therefore

necessary to evaluate the overall performance, benefits, and limitations of aquatic insects as biological control agents.

The present article aims to review and analyse available literature on the role of aquatic insects in controlling aquatic weeds. Particularly, it seeks to (a) To study major insect agents used in aquatic weed management, (b) To assess their effectiveness and ecological impacts, and (c) To identify challenges and future prospects for integrating insect biological control into sustainable aquatic weed management strategies.

The reasons to use Insects for Aquatic Weed Control-

Biological control helps natural herbivores which specialise on invasive plants, reducing populations over time without constant chemical inputs. Insects are striking biocontrol agents because many exhibit: Host specificity, feeds primarily on the target weed without harming native plants; Self-sustaining populations, significantly they can persist and continue control over several years; Less environmental impact in comparison to chemical herbicides. Worldwide research has documented both challenges as well successes in insect-mediated control of aquatic weeds.

Overview of Aquatic Weed Biocontrol with Insects

Biological control of aquatic weeds includes the introduction of herbivorous insect species which feeds specifically on target plants species, hence reducing biomass by slowing the growth. In some cases, this approach facilitates improvement of native vegetation and restoration of functions of ecosystem.

A pioneer review by Bennett (1977) examined early insect introductions against major aquatic weeds and proposed methodologies for selection, host-specificity testing, and release of plant eating insects[1]. In recent time best management practice (BMP) guideline provides successes and failures of technical evaluation of agent, by emphasizing post-release monitoring and adaptive management[2].

Study Area: Jharkhand

Jharkhand is located in eastern India between approximately 21°58′ –25°18′ N latitude and 83°22′ –87°57′ E longitude. The state is situated on the Chota Nagpur Plateau and is characterized by undulating terrain, forested landscapes, and a tropical monsoon climate. The average annual rainfall ranges from 1,200 to 1,400 mm, with most precipitation occurring during the southwest monsoon season (June–September). These climatic

conditions support the development of numerous natural and man-made freshwater bodies.

The freshwater resources of Jharkhand include reservoirs, dams, rivers, wetlands, and thousands of village ponds. Major reservoirs and dam systems such as Maithon Reservoir, Panchet Dam, Tenughat Dam, Chandil Dam, and Patratu Reservoir form part of the Damodar Valley and Subarnarekha river systems. These reservoirs serve multiple purposes, including irrigation, hydropower generation, flood control, and fisheries, but are frequently affected by aquatic weed infestations.

In addition to large reservoirs, small ponds, tanks, oxbow lakes, and seasonal wetlands are widespread across rural and peri-urban areas of Jharkhand. These water bodies are particularly vulnerable to nutrient enrichment from agricultural runoff, domestic effluents, and organic waste, creating favourable conditions for the proliferation of floating and submerged aquatic weeds. Water hyacinth and water lettuce are especially dominant in stagnant and slow-moving waters, while submerged weeds such as hydrilla occur in clearer and deeper ponds and reservoirs.

The combination of tropical climate, nutrient availability, and diverse aquatic habitats makes Jharkhand an ecologically suitable region for both aquatic weeds and their associated insect herbivores. This provides an opportunity to explore the potential of aquatic insect-based biological control as a sustainable management strategy tailored to the state's freshwater ecosystems.

Table 1: - Jharkhand-Specific Aquatic Weed Species

Weed Species	Common Name	Type	Habitats in Jharkhand	Ecological & Socio-Economic Impact	Potential Insect Biocontrol Agents
Eichhornia crassipes	Water Hyacinth	Floating	Reservoirs, ponds, canals (e.g., Maithon, Panchet)	Obstructs water flow, reduces dissolved oxygen, affects fisheries	*Neochetina eichhorniae, Neochetina bruchi:* are highly effective host-specific weevils that damage leaves and petioles, reducing plant vigour and spread.
Pistia stratiotes	Water Lettuce	Floating	Ponds, slow-flowing rivers, wetlands	Impedes irrigation, reduces fish productivity	*Cyrtobagouss alviniae (experimental)* and other potential herbivorous insects have shown promise in reducing biomass under controlled conditions.

Salvinia molesta	Giant Salvinia	Floating	Ponds, reservoirs, slow rivers	Dense mats, decreases oxygen, affects biodiversity	*Cyrtobagous salviniae* is the most successful classical biocontrol agent worldwide; *Megamelus scutellaris* has also been explored for suppressing aquatic weeds.
Hydrilla verticillata	Hydrilla	Submerged	Clear ponds, reservoirs, canals	Competes with native plants, reduces water flow	*Hydrellia pakistanae, Bagous hydrillae* attack stems and leaves, weakening plant growth and spread.
Alternanthera philoxeroides	Alligator Weed	Emergent	Wetlands, shallow margins of ponds	Reduces irrigation efficiency, displaces native species	*Agasicles hygrophila* is an effective host-specific beetle that defoliates the weed and suppresses vegetative growth.
Ipomoea aquatica	Water Spinach	Floating/ Emergent	Agricultural ponds, wetlands	Competes with crops, reduces aquatic biodiversity	Experimental studies indicate possible use of leaf-feeding beetles and caterpillars, though no major standardized insect biocontrol agent has yet been widely adopted.
Egeria densa	Brazilian Waterweed	Ponds, reservoirs	Submerged	Dense mats, obstructs irrigation and fisheries	*Hydrellia* species have shown experimental potential for biological suppression in integrated weed management programmes.

This table highlights major invasive aquatic weeds commonly found in the freshwater ecosystems of Jharkhand and their ecological as well as socio-economic impacts. These weeds form dense floating or submerged mats that obstruct irrigation channels, reduce dissolved oxygen, suppress native biodiversity, and negatively affect fisheries, agriculture, and water management systems. The table also emphasizes the importance of biological control using host-specific insect agents such as weevils, beetles, and leaf-mining flies, which offer environmentally sustainable alternatives to chemical weed management. Overall, integrated biocontrol approaches can play a significant role in restoring aquatic ecosystem health and improving water resource productivity in the region.

Major Insect Agents and Target Weeds

(a) *Neochetina* Weevils on Water Hyacinth

The weevils *Neochetina eichhorniae* and *Neochetina bruchi* have been widely deployed to manage *Eichhornia crassipes*. These insects weaken plants through feeding on leaf and petiole, which increases susceptibility to pathogens and environmental stress. A recent review shows their

biology, feeding ecology, and global establishment success highlights their continued importance in water hyacinth management programmes[3]. Large-scale programmes in Africa and other regions have documented substantial suppression following establishment[4].

(b) *Megamelus scutellaris* Planthopper

Megamelus scutellaris, a sap-feeding planthopper, damages *Eichhornia crassipes* by extracting plant sap and reducing chlorophyll content. In Florida and parts of Africa study reflects the measurable reductions in plant vigour under favourable conditions[2]. Weevils on Salvinia and Water Lettuce[6].

The weevil *Cyrtobagous salviniae* has achieved long-term control of giant salvinia in several regions, representing one of the most successful cases of aquatic weed biocontrol[4]. Similarly, *Neohydronomus affinis* has been found managing water lettuce. Programme evaluations indicate that successful establishment depends on climatic suitability and sustained monitoring[5].

(c) Alligator Weed Flea Beetle

The leaf beetle *Agasiclesh hygrophila* feeds intensively on alligator weed, causing defoliation and plant mortality when feeding pressure is high. Its establishment in the southeastern United States and other regions has led to effective suppression in suitable habitats[1,4].

(d) Leaf-Mining Flies on Hydrilla

The shore fly *Hydrellia pakistanae* targets *Hydrilla verticillata* by feeding on leaf tissue during its larval stage, reducing photosynthetic capacity and causing plant mats to fragment. This agent contributes to integrated hydrilla management strategies[2].

(e) Integrated Approaches and Synergy with Other Methods

Insect biological control is often most effective within integrated management frameworks. Research has demonstrated that herbivory by established insect agents enhances herbicide uptake and effectiveness in water hyacinth management[7]. This synergy allows for reduced herbicide dosages while maintaining suppression.

Recent collaborative studies integrating classical biological control insects with optimised herbicide rates and coverage further support adaptive, combined management strategies for *Pontederia crassipes* (formerly *Eichhornia crassipes*)[7].

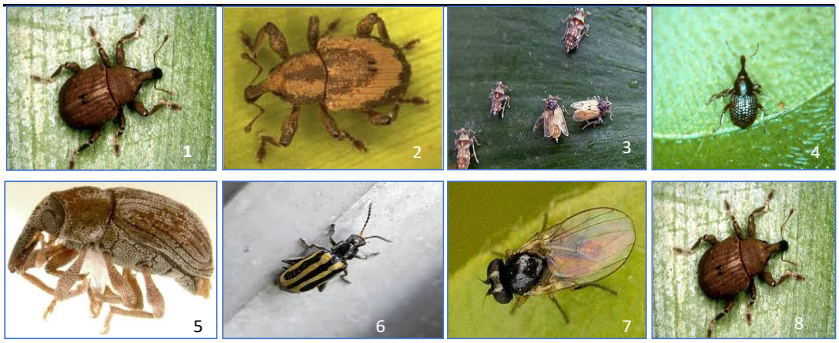


Fig. 1: ***Neochetina eichhorniae*****, 2.** ***Neochetina bruchi*****, 3.** ***Megamelus scutellaris*****, 4.** ***Cyrtobagous salviniae*****, 5.** ***Neohydronomus affinis*****, 6.** ***Agasiclesh hygrophila*****, 7.** ***Hydrellia pakistanae*** **8.** ***Neochetina eichhorniae***

(f) Successes, Limitations, and Influencing Factors

Successes

Biological control with insects has considerably reduced aquatic weed populations in several regions. In South Africa and other parts of Africa, long-term programmes have restored waterway functionality and reduced management costs[4,5].

Limitations

Outcomes vary depending on climate, predator pressure, nutrient status, and release timing. Some agents fail to establish or achieve effective densities. BMP assessments emphasize the importance of ecological matching and post-release evaluation [2].

Ecological Influences

Environmental variables like water temperature, nutrient load, and trophic interactions strongly influence agent performance. Foundational ecological principles underlying these interactions were highlighted in early evaluations of aquatic insect biocontrol systems[1].

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