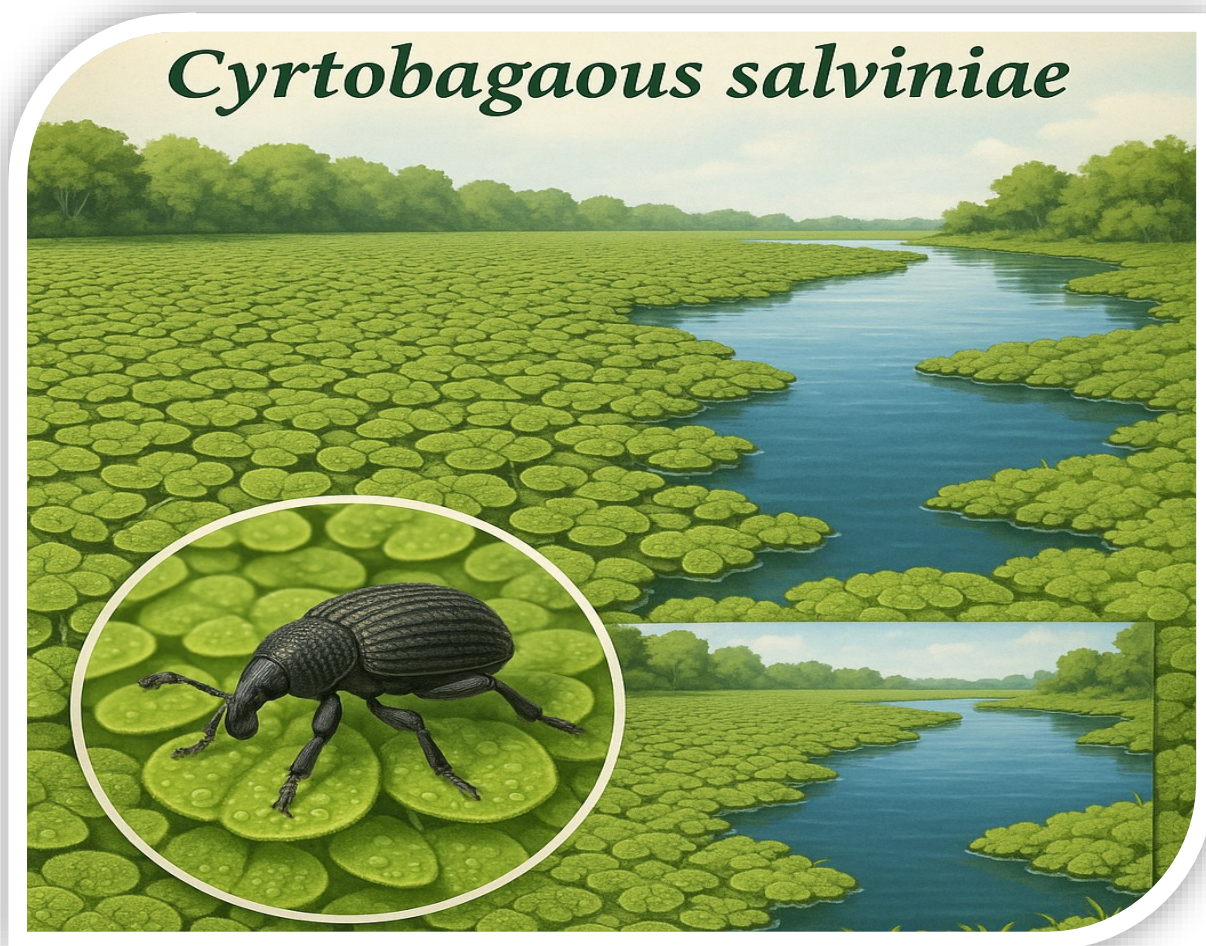


Biological control of water fern (*Salvinia molesta*) using *Cyrtobagous salviniae*



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Introduction

Salvinia molesta, commonly known as water fern or Kariba weed, is a free-floating aquatic fern native to South America that has become one of the most aggressive and problematic aquatic weeds in tropical and subtropical regions around the world, including India. It has rapidly invaded rivers, lakes, ponds, canals, and reservoirs, particularly in the central Indian states of Madhya Pradesh, Maharashtra, and Chhattisgarh. The weed thrives in nutrient-rich and stagnant water bodies, where it forms dense, impenetrable mats on the water surface.

The proliferation of *S. molesta* leads to a cascade of environmental and economic problems. The thick surface cover obstructs sunlight penetration, thereby hampering photosynthesis in submerged aquatic flora. It also reduces dissolved oxygen levels, negatively impacting fish populations and other aquatic life. Moreover, the weed interferes with water flow, irrigation, and drainage systems, clogs hydroelectric equipment, and exacerbates the risk of flooding during the monsoon season. These impacts pose serious threats to water resource management, aquatic biodiversity, and rural livelihoods dependent on fishing and irrigation.

Conventional control methods, such as mechanical removal and chemical herbicides, have proven to be inadequate or unsustainable. Mechanical removal is labor-intensive, time-consuming, and expensive—particularly in large water bodies. It also often results in only temporary relief due to rapid regrowth from vegetative fragments. Chemical control, on the other hand, poses risks of toxicity to non-target aquatic organisms and contamination of water used for domestic, agricultural, and industrial purposes.

In response to these challenges, biological control using the host-specific insect *Cyrtobagous salviniae* has emerged as a scientifically validated, ecologically safe, and cost-effective solution. Native to the same regions as *S. molesta*, this weevil species has been successfully deployed for the suppression of the weed in various countries, including India. The adult weevils feed on the apical buds of *Salvinia*, inhibiting its growth, while the larvae tunnel into the rhizomes and stems, causing structural damage and internal decay. This dual mode of attack leads to progressive desiccation, collapse, and ultimate eradication of the weed mat.

Methodology

The methodology is based on the use of the host-specific insect bioagent *C. salviniae*, a weevil known for its efficacy in suppressing *S. molesta* populations under tropical and subtropical climatic conditions.

1. Baseline Survey and Infestation Mapping:

An extensive survey was conducted to identify and map the extent of *S. molesta* infestation across various regions. A total of 12 water bodies in Maharashtra, 9 in Madhya Pradesh, 3 in Chhattisgarh, and 1 each in Haryana, Uttarakhand, Tamil Nadu, and Odisha were found heavily infested. Additionally, severe infestations were reported in rice fields in Balasore (Odisha) and Bhandara (Maharashtra). These findings underscored the urgent need for an effective, scalable control strategy.

2. Introduction and Acclimatization of Bioagent

Weevils of *C. salviniae* were initially sourced from Kerala and introduced into experimental conditions at ICAR-DWR, Jabalpur, to test their adaptability and reproductive capacity in the agro-climatic conditions of central India. The insects successfully acclimatized, showed robust multiplication, and demonstrated significant feeding activity on *S. molesta*, confirming their suitability for field-level application.

3. Controlled Tank Studies and Release Rate Optimization

To optimize release rates and augmentation intervals, controlled studies were conducted in concrete tanks (2.63 m² area each) where *S. molesta* was allowed to establish for one month. Three different initial release densities of the weevil (4.56, 6.84, and 9.13 individuals/m²) were tested, followed by periodic augmentative releases:

- Bimonthly augmentation: 6.84 individuals/m²
- Quarterly augmentation: 4.56 individuals/m²
- Six-monthly augmentation: 6.84 individuals/m²

Observations were recorded initially at a 3-month interval post-release, followed by every two months. A significant increase in the weevil population was recorded after 3 and 5 months, corresponding to both initial and augmentative releases.

The feeding behavior of the bioagent was also monitored by assessing the proportion of damaged vs. undamaged *S. molesta* growing buds. While undamaged buds initially outnumbered damaged ones, a reversal was observed by the fifth month, indicating effective suppression by the bioagent and validating the efficiency of augmentation schedules.

4. Mass Multiplication of Bioagent

Following successful tank trials, a large-scale multiplication program for *C. salviniae* was established at ICAR-DWR. The weevils were reared under controlled conditions and provided with fresh *S. molesta* biomass as host material. Mass-reared weevils were used for release into infested field sites.

5. Field-Level Releases and Monitoring

Field-level releases were carried out in infested water bodies across Madhya Pradesh, Maharashtra, Chhattisgarh, and Haryana. The standard release rate adopted was approximately 22,500 adult weevils per hectare, with 3–4 augmentations at 3-month intervals using *Salvinia*-infested plants carrying established weevil populations.

6. Outcome and Timeline

In all implementation sites, visible suppression of *S. molesta* was observed within 5–6 months of the initial release. Complete control and restoration of water clarity were typically achieved within 15–18 months, depending on site conditions and augmentation efficiency.

Implementation Protocol:

Beetle Release Density	Approx. 22,500 adult beetles/ha
Follow-up Strategy	At 3-month intervals, <i>Salvinia</i> plants infested with developing beetles are redistributed across the weed-infested waterbody.
Feeding Behavior	- Adults feed on the apical buds, suppressing new growth. - Larvae bore into rhizomes and stem tissues, weakening the plant internally.
Control Timeline	Complete suppression and desiccation achieved within 15–18 months.
Post-Control Impact	Restoration of open water surface, improved oxygenation, revitalization of aquatic life.

Results

The ICAR-Directorate of Weed Research, Jabalpur has successfully demonstrated this technology at multiple locations across the central India:

Location	Area Treated	State
Padua Village Pond, Katni	50 acres	Madhya Pradesh
Ghodapet Pond, Chandrapur	110 acres	Maharashtra
Junona Lake, Chandrapur	750 acres	Maharashtra
Irai Dam, Chandrapur	250 acres	Maharashtra
Lanjad Pond, Gadchiroli	40 acres	Maharashtra
Hatti Pond, Gadchiroli	150 acres	Maharashtra
Talpuri Lake, Durg	40 acres	Chhattisgarh

Before the release of insect Bioagents



After the release of insect Bioagents



Satpura reservoir at STPS, Sarni, Madhya Pradesh



Padua village pond, Katni, Madhya Pradesh



Talpuri Lake, Durg District, Chattisgarh



Junona Lake, Chandrapur, Maharashtra

Benefit

Impressed by the demonstrated success, Madhya Pradesh Power Generating Company Limited (MPPGCL) entrusted ICAR-DWR with a consultancy project to control *S. molesta* biologically in the Satpura Reservoir (approx. 2,900 acres) at the Satpura Thermal Power Station, Sarni, Betul district. According to MPPGCL officials, manual or mechanical removal of *S. molesta* was estimated to cost ₹15 crores and require up to five years. In contrast, biological control using *C. salviniae* proved to be cost-effective, environmentally sustainable and self-perpetuating.

Upscaling

Given the ecological success and economic viability demonstrated through large-scale deployments in central India, there is a strong case for further upscaling of the biological control program using *C. salviniae*. The infestations of *S. molesta* are not limited to a few isolated water bodies; they represent a recurring and expanding challenge across diverse agroecological zones. To address this issue at scale, it is imperative to institutionalize a coordinated, multi-agency implementation strategy.

Proposed Upscaling

1. National Coordination and Policy Support

- Integration of biological control protocols into national and state-level aquatic weed management programs under Ministry of Agriculture & Farmers' Welfare and Ministry of Jal Shakti.
- Recognition of *C. salviniae* release and monitoring guidelines under standard operating procedures (SOPs) for invasive weed control.

2. Regional Mass Rearing and Supply Chain Development

- Establishment of regional mass multiplication and distribution centers at Krishi Vigyan Kendras (KVKs), Agricultural Universities, and ICAR institutes in high-risk zones.
- Training of local staff in bioagent rearing, quality control, and field release techniques.
- Development of decentralized “Bioagent Production Kits” for community-level deployment.

3. Digital Monitoring and Decision Support Systems

- Launch of a centralized web-based platform or mobile app to:
- Geo-tag infestation sites.
- Track release events and bioagent establishment.
- Record weed suppression progress through satellite and drone imagery.

- Citizen science integration for real-time reporting and feedback from local stakeholders (farmers, fishers, panchayats).

4. Stakeholder Engagement and Capacity Building

- Awareness programs and farmer field schools (FFS) to promote community participation in biological control efforts.
- Demonstration units at district levels showcasing before–after scenarios.
- Engagement with power generation units, irrigation departments, and fisheries for collaborative implementation.

5. Economic Incentives and Sustainability Models

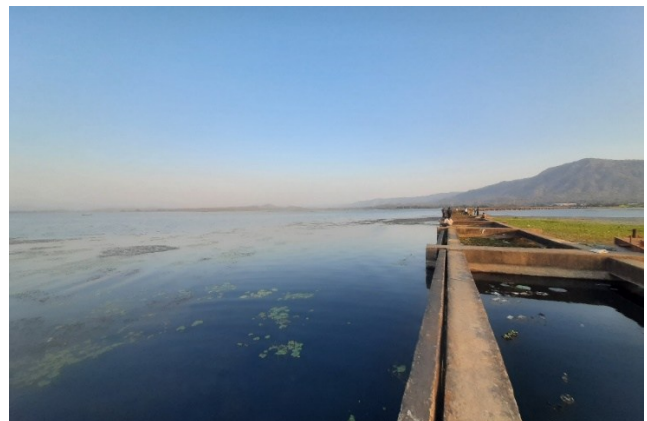
- Financial incentives/subsidies for biological control adoption in rural water bodies under schemes like MGNREGA, RKVY, and PMKSY.
- Inclusion of biological control-based weed management as an eligible activity under CSR initiatives for industries dependent on water resources (e.g., thermal power plants, fisheries, drinking water boards).
- Encouragement of public-private partnerships (PPPs) for scale-out, particularly in urban lakes and industrial reservoirs.

Recommendations for Adoption

- Prior mapping of infestation areas and baseline weed biomass assessment.
- Establishment of on-site beetle multiplication units if required.
- Collaboration with local stakeholders (fisheries, irrigation, power generation units).
- Periodic monitoring of beetle establishment and weed suppression progress.
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Satpura reservoir before the release of insect bioagents



Satpura reservoir after the release of insect bioagents



Satpura reservoir free from *S. molesta*



Restoration of fishing activities in Satpura reservoir

For more information contact

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