swamps and hilly tracts of the Western Ghats and Himalayas; it can be assumed that tigers may acclimatize the local conditions and roam freely across the Panna and Ranipur landscape and tourists would be able to observe tiger's roar.

As it is expected that the tigers may seek refuge in parts of the RTR and other adjoining protected habitats, understanding the behaviour and ecology of tigers and their habitats across the Panna–Ranipur landscape, the availability of prey species and the evaluation of management and effectiveness of protected habitats are some of the important aspects to be considered for demonstrating a successful model of the relationship between people and wildlife. Further, mapping movement tracks and crucial corridors and identifying potential threats would strengthen our conservation actions.

Considering the rapid change in the climate and environmental conditions, it is important to prioritize the environmental and governance challenges. Besides, opportunities and challenges are also needed to be identified regarding large landscape management and conservation, which should foster a set of conservation initiatives and actions of research, policy, financing and actions. Moreover, a strategic framework needs to be developed covering various important aspects like water, biodiversity, climate, livelihood and economic and fiscal profile, involving all stakeholders, especially local communities.

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Localized eradication of mango stone weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionidae) in India

The mango stone (nut) weevil (*Sternochetus mangiferae*) is a monophagous pest of mango, *Mangifera indica.* It is found in almost all the mango-growing areas of the world, except Egypt, Italy, Israel and the Canary Islands[1]. In India, it is found mainly in the south[2]. The adults lay eggs on immature fruits of 2–4 cm diameter. The grubs that hatch bore into the core of the fruit and eventually get enveloped by the seed coat. The grubs pass through five instars and pupate within the seed. The adults that emerge from the seed burrow through the pulp and emerge through a hole in the rind[3,4]. During this process, they damage the pulp and contaminate it with their excreta, making it unfit for market, export and industry[5]. The overall loss varies from 5% to 80% (ref. 5). Early infestation can also lead to fruit drop[6,7]. The weevil is of quarantine significance in fresh fruit export[5].

The adults which emerge during fruiting (between June and August) were found to generally rest on the main tree trunk and the base of primary branches at their junction with the main trunk[3,4]. These adults are in a state of rest/inactivity up to the following season when fruit formation takes place (by February/March of the following year). The adults at that stage stir out of their inactive phase, mate and oviposit on the immature fruits, and thus the life cycle repeats[4]. Once the grubs enter the seed core of the fruit, they are not susceptible to any insecticides[8]. Moreover, chemical sprays cannot be used at the immature fruit stage of the tree, as the young fruits are used in pickles and chutneys in India. The present recommendation for the weevil is spraying decamethrin 0.0028% at the lime size of the fruit, coinciding with egg-laying. Even a safe insecticide like azadirachtin was found ineffective against the weevil[8]. In mango, prior to flowering, it is a common practice to spray imidacloprid 17.8% @ 0.4 ml/l to control mango hoppers (*Idioscopus* spp.)[9]. This insecticide is widely used by farmers to protect the inflorescence from hopper damage, which is crucial for good fruit set[8,9].

With the knowledge that adult weevils of *S. mangiferae* are found on the tree trunk[3,4], we tweaked the hopper spray schedule and applied it all over the trunk, branches and

full canopy. Only one spray was applied during pre-bloom in December–January. Our objective was to target the stone weevils on the trunk and branches by default while the hoppers were being controlled[10]. We used this approach in a mango orchard (~40 acres) with mixed varieties, viz. Alphonso, Totapuri and Neelum (all stone weevil-susceptible) of 25–30-year-old mango trees. The study was initiated in 2008 in Latteri (12.971062N, 79.067877E), Vellore district, Tamil Nadu, South India. With the help of the farmers, we sampled 300 randomly selected fruits of cv. Totapuri (a susceptible variety) at every harvest from 2008 to 2022. Sampled fruits were cut, and seeds were chiselled for the presence of weevils. Sampling was repeated every year up to 2022.

Sampling was also done in another orchard at Gudiyatham (12.943619N, 78.873226E) variety Totapuri, about 15 km away from Latteri, where imidacloprid was sprayed once during pre-bloom to the whole canopy to control the mango hoppers. The fallen fruits during harvest, which also indicate the presence or absence of weevils, were randomly cut ($n = 140$ fruits). According to the farmers, this orchard usually recorded 50–70% stone weevil infestation. Here, fallen fruit sampling has been done since 2012. However, in 2015, the farmers also started full tree sprays (canopy + branches + trunk). The following year, they witnessed a decline in weevil infestation (Figure 1).

In Latteri, the infestation dropped from 55.66% in 2009 to 1.00% in 2015; thereafter, the percentage infestation was zero. In Gudiyatham, the percentage infestation of stone weevil was zero in 2019, clearly showing that in both places, stone weevil was locally being eradicated (Figure 1).

A third sampling of harvested fruits from the National Plant Protection Organization (NPPO)–Directorate of Plant Protection Quarantine and Storage (DPPQS) and Agricultural and Processed Food Products Export Development Authority (APEDA) approved irradiation facility at Malur, Karnataka was carried out. These mangoes were to be exported after irradiation treatment and were from different districts of South India (Figure 2). Each consignment (var. Banganapalle) was sampled area-wise, and 200 fruits were randomly selected and examined for the presence and absence of stone weevils under the supervision of the staff from the DPPQS, Government of India (GoI). Orchards followed the recommendations of ICAR-Indian Institute of Horticultural Research, Bengaluru and those

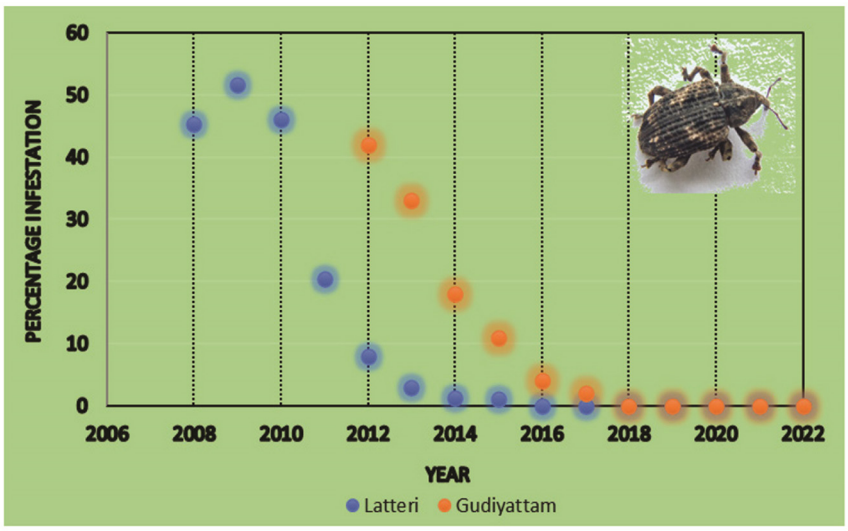

Figure 1. Decline in the percentage of weevil infestation over the years in Latteri and Gudiyatham, Tamil Nadu, India.

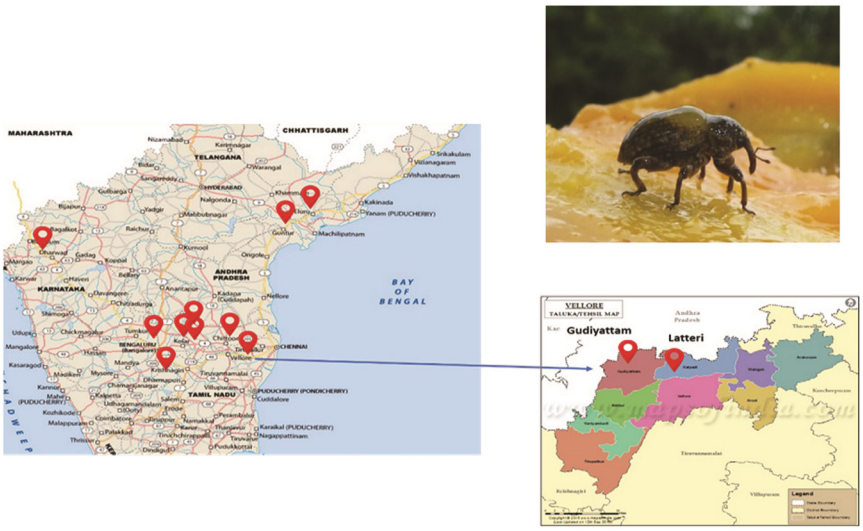

Figure 2. Eradication of weevil infestation in high-end market and export-focused mango orchards of Karnataka, Andhra Pradesh, Telangana and Tamil Nadu, India.

Table 1. Infestation of stone weevils recorded maximum of 1% from 2018 to 2022 in the surveyed orchards registered by Agricultural and Processed Food Products Export Development Authority and Departments of Horticulture

Year	2018	2019	2020	2021	2022
Chittor	1	0	0	0	0
Krishna	0	0	0	0	0
Nuzvid	0	0	0	0	0
Bhadradri	0	0	0	0	0
Krishnagiri	0	0	0	0	0
Kolar	1	0.5	0	0	0
Srinivasapura	0.5	0.5	0	0	0
Chintamani	1	0.5	0	0	0
Ramanagara	0	0	0	0	0
Dharwad	0	0	0	0	0

registered by APEDA and the state Departments of Horticulture could alone bring fruits to the irradiation facility at Malur. The present study was carried out from 2018 to 2022. Infestations in the fruit ranging from 1% to 0% were recorded from 2018 to 2022 in Chitoor, Kolar, Srinivasapura and Chitanmani, whereas Krishna, Nuzvid, Bhadradri, Krishnagiri, Ramanagara and Dharwad showed zero percentage infestation (Figure 2). From 2020 to 2022, no infestation was found in any of the consignments arriving at the mango pack house at Malur. It is clear from this study that wherever pre-harvest intervention had been taken up, stone weevils were not recorded, and the fruits were fit for export. If this approach is widely adopted, like in the cotton boll weevil (*Anthonomus grandis*) of USA[11], the stone weevil can be potentially eradicated from India (Table 1).

The above-mentioned regions are potential areas of low pest prevalence for mangoes. Till date, the areas declared as pest free area (PFA) of *S. mangiferae* are the production areas of Navsari and Valsad in Gujarat; Devgad, Kudal, Malvan, Sawantwadi and Vengurla in Maharashtra and Barbanki, Malihabad and Saharanpur in Uttar Pradesh[10,12].

This study indicated that interventional pre-harvest full-tree sprays locally eradicate stone weevils. Once eradicated, the weevils are unlikely to reinfest on account of their long univoltine life cycle and being clumsy fliers. Therefore, if reinfestation is not recorded for at least for three continuous years the area can be declared as low prevalence area fit for sourcing fruits for export.

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