crops. Generally, for establishment of newly planted mango orchard, Rs 1 lakh is required for the cost of planting material, fertilizer, pesticide, labour, fencing with locally available material and miscellaneous cost. With the introduction of doba in 1 ha of land, the total cost amounts to Rs 1.48 lakhs during the first year of orchard establishment. The gestation period for mango orchards is 3 years and with doba technology, actual benefit will start to accrue after 4 years at the estimated rate of Rs 1 lakh/ha (yield: 4000 kg/ha). The inter-space between mango plants can be utilized for growing intercrops during the initial period and provides some remuneration to overcome cost incurred in the establishment and management of the orchard. Further, the harvested residue of intercrop is used as dry mulch in the surface of root zone of mango plant to conserve water. The payback period for mango orchard is 4 years, i.e. the cost involved for the establishment is met from the income at the fifth year of establishment. The benefit–cost ratio of 2.3 : 1 is achieved in the sixth year of establishment with doba technology due to 100% survival. In case of conventional method (no doba) of irrigation, the payback period is 5 years with benefit–cost ratio of 0.87 : 1 in the seventh year of establishment due to 50% mortality of the orchard. Owing to its low cost and ease of construction, the doba technology has been readily accepted by the farmers. They have agreed to convert their low productive land into mango orchards and use doba to harvest rainwater during establishment phase of the orchards. Life-saving irrigation from doba has resulted in no mortality of plants, particularly during the summer months and better growth. The plastic-lined doba is also being used by farmers for the purpose of storing water from seasonal streams and using it during the summer season. This technology has helped the farmers to increase their income and to also diversify the crops to meet their nutritional requirements.

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Need to strengthen quarantine between Andaman and Nicobar Islands and mainland India

When an animal or a plant species, unknown in a country, gets introduced, it is termed an exotic species often characterized by its prolific breeding, in the absence of any biotic natural enemies. Frequently, such introduced species end up as a pest/weed. These then become invasive alien species (IAS), threatening the economy. Often only those that acclimatize stay on to cause economic loss like *Parthenium* (*Parthenium hysterophorus*)[1], *Salvinia* (*Salvinia molesta*)[2], serpentine leaf miner (*Liriomyza trifolii*)[3], spiralling white fly (*Aleurodicus dispersus*)[4] and the recent pinworm (*Tuta absoluta*)[5], to mention a few. Only few of the invasives have been curbed successfully. The two best examples are the papaya mealy bug, *Paracoccus marginatus* and water fern, *Salvinia molesta*. The former has been controlled by bouquet of exotic natural enemies, the most important being, *Acerophagus papayae*[6]. The water fern, *Salvinia* which blocked waterways in Kerala, was controlled successfully by a beetle, *Cryptobagous salviniae*[2]. India has been advocating rigorous screening at ports of international entry to prevent exotic introduction. However, national restriction or screening of live materials, between regions/states, as is being done, for example, in Australia (between counties) and USA (between Islands and the mainland) is hardly evident in India, but is becoming a critical need of the hour. The only exceptions are the restrictions put on the golden cyst nematodes which were prevalent in Ooty[7] and apple codling moth (*Cydia pomonella*) which was present in Kashmir[8]. The former perhaps helped in salvaging potato in most parts of North India, where it is almost a staple food. Other insects/diseases with domestic quarantine in India are fluted scale (*Icerya purchasi*), San Jose scale (*Aspidiotus perniciosus*), coffee berry borer (*Hypothenamus hampei*), potato wart (*Synchytrium endobioticum*), banana mosaic (virus) and banana bunchy top (virus)[9]. The movements of these however, seem hardly restricted.

One such 'intra-national' restriction on live material urgently needed is between Andamans and Nicobar Islands and mainland India. Fortunately, much of these islands are maintained natural, and hence an introduced species, even from the mainland may not be noticed to affect agriculture, but can cause some negative biodiversity impacts. However, introduced species in the mainland can be more pronounced, especially if they infest agricultural crop plants. To make this point loud and clear, we quote here a case study of a mango borer, *Citripestis eutraphera* (Lepidoptera: Pyralidae).

The borer was first reported in Andamans on a wild mango *Mangifera andamanica* by Bhumannavar[10]. It was probably restricted to the Islands for almost two decades, till 2014, when it was reported by Jayanthi *et al.*[11] from South India on *M. indica*, a cultivated mango. The only possibility of its introduction to the mainland was probably through human-related movements. The question then arises whether an infested fruit ever got to enter the mainland, probably through the Chennai port. If a rotting fruit post-entry gets discarded, it can become a primary source of introduction. It is difficult to track the routes and points of entry and at best, one can only be speculative. A survey in 2015 showed that *Citripestis eutraphera* is fairly well-established in Kolar, Bengaluru Rural and Hassan districts of Karnataka. They were found infesting lime-sized mango fruits up to preharvest, when serious fruit rotting on tree sets in.

As advanced stage of infestation is rotten fruits which can be detected, it is unlikely that mature fruit brought from the Andamans must have inadvertently resulted in the introduction of the insect. It then most probably be the early stages (lime-sized) used for pickles, which have been brought by tourists, from the Andamans. Chances are that these mangoes with larvae may have got discarded as kitchen waste, a probable route of introduction. Another possibility is that *C. eutraphera* must have existed in the mainland and may have gone undetected by its sheer low numbers, and caught attention, when infestation became noticeable. However, this may be ruled out as regular surveillance of pests and diseases is being done by the Indian Council of Agricultural Research.

In order to assess how serious *C. eutraphera* is for commercial mango growers, traders and markets, a case study was conducted at the Indian Institute of Horticultural Research (IIHR), Bengaluru, India (12°58′N; 77°35′E). Observations were carried out on three commercial varieties, viz. Alphonso, Banganpalli and Totapuri. Ten mango

Table 1. Number of mango fruits infested by *Citripestis eutraphera* during different stages of the fruit and percentage infestation during 2014–15 (cv. Alphonso)

Fruit stage	Date (2014)	No. of fruits/ ten trees	Date (2015)	No. of fruits/ ten trees
Pea	6–27 March	0	18 March–9 April	0
Marble	12 March–16 April	6	25 March–23 April	12
Lime	19 March–23 April	129	1 April–7 May	100
Mature	9 April–21 May	70	23 April–21 May	28
Fully grown	7–28 May	0	21 May–3 June	0
Harvested fruits	1 June	0	9 June	0
Infestation (%)	–	6.83	–	8.5

Table 2. Number of mango fruits infested by *Citripestis eutraphera* during different stages of the fruit and percentage infestation during 2014–15 (cv. Totapuri)

Fruit stage	Date (2014)	No. of fruits/ ten trees	Date (2015)	No. of fruits/ ten trees
Pea	19 February–12 March	0	12 March–9 April	0
Marble	26 March–10 April	4	25 March–30 April	5
Lime	12 March–16 April	59	9 April–7 May	23
Mature	9 April–14 May	51	23 April–21 May	32
Fully grown	30 April–28 May	2	7 May–4 June	4
Harvested fruits	30 May	0	12 June	0
Infestation (%)	–	3.87	–	3.65

Table 3. Number of mango fruits infested by *Citripestis eutraphera* during different stages of the fruit and percentage infestation during 2014–15 (cv. Banganpalli)

Fruit stage	Date (2014)	No. of fruits/ ten trees	Date (2015)	No. of fruits/ ten trees
Pea	19 March–23 April	0	18 March–16 April	0
Marble	2 April–7 May	4	25 March–7 May	4
Lime	16 April–28 May	59	9 April–21 May	55
Mature	14 May–25 June	51	7–28 June	21
Fully grown	18 June–7 July	2	4 June–1 July	4
Harvested fruits	10 July	0	4 July	0
Infestation (%)	–	2.46	–	4

Figure 1. ***a***, Adult moth of *Citripestis eutraphera*; ***b***, Infested mango fruit with split and rot.

trees out of 25 in an orchard were randomly selected in each variety and sampled once a week with size of fruits showing pea (~10 mm diameter), marble (~20 mm diameter), lime (~35 mm diameter), mature (preharvest) and fully grown (almost ready for harvest). The observations were taken by scanning the entire canopy of a tree and the number of fruits infested (evident by bored holes, rotting or decayed fruits) was counted in terms of number of fruits/tree at harvest during 2014 and 2015. All the harvested fruits were again examined for infestation at harvest and a week on shelf by examining 20 fruits from ten random trees of each variety ($n = 200$). The mean yield of each variety was recorded to calculate the percentage infestation of mango fruit. The specimens were morphologically identified at the Indian Agricultural Research Institute while molecular confirmation was done at the National Bureau of Agricultural Insect Resources.

It was found that in all the varieties there was no infestation at pea size of mango. The first infestation was seen at marble size of the fruit, which was low in number. By the next stage within a week when fruit attained lime size, the number of fruits damaged was 129 and 100 in Alphonso (Table 1), 59 and 23 in Totapuri (Table 2), and 59 and 55 in Banganpalli (Table 3) in 2014 and 2015 respectively. In mature fruit it was 70 and 28 in Alphonso (Table 1), 51 and 32 in Totapuri (Table 2) and 51 and 21 in Banganpalli (Table 3) in 2014 and 2015 respectively. In the early stages of marble and lime size, the infested fruits dropped. However, mangoes attacked in mature and fully-grown stages remained on the tree, but the number of fruits damaged in mature stage was less than at lime size stage of mango. It was further found that in the harvested fruit and subsequently on the shelf, there was no infestation. These moths (Figure 1 *a*) usually lay eggs <1 mm on the rind of the fruit, which is also corroborated by Anderson and Tran-Nguyen[12]. Generally, 1–3 larvae are found in infested fruits. Damaged fruit when examined had no pupa inside. So, it can be assumed that pupation took place in the soil or in fallen fruits which has also been reported by Anderson and Tran-Nguyen[12]. The lifespan of an adult moth is about a week and the female lays 125–450 eggs. Larva lives for 12–15 days by feeding on the mango pulp and tender seed. At early stages of the fruit, pupation takes place in silken cocoon in the soil adjacent to the fallen fruits and it takes 14–15 days for adult emergence[10]. Infestation percentage varied from 2.46 to 8.5 in the two years, across varieties. Alphonso seems to be more susceptible and hence this pest may potentially become economically important in future. In early stages the fruits drop, but later infestations manifest as rotting and split fruits (Figure 1 *b*) on the tree which do not drop. The evidence gathered shows that the insect has indeed become a potential pest of mango, the main fruit crop of India[13].

It was seen that up to lime size of fruit, the larvae also fed on the soft seeds. This perhaps caused fruit fall as found in case of stone weevil, *Strenochetus mangiferae* Fab, when initial attack on seeds, led to the shedding of the fruits[14,15]. In India, it is common to gather such fallen fruits which are sold in the market for pickle or chutney making. At this stage rot or boring the fruit by *Citripestis eutraphera* is not evident. Therefore it can be a source of spread of the insect through market chain. When seed becomes hard only the flesh is eaten, but infested fruits do not drop, probably as seeds are not damaged.

The present study shows that this pest has only a low market or quarantine risk as there was no evidence of infestation at preharvest (i.e. at 80% maturity) in the harvested fruit or subsequently a week into post-harvest on the shelf. As only fresh mature fruits are exported, it is safe. In later stages of the fruit, rot quickly sets in and gets culled in the field itself. So, even from a regional perspective, the risk of spread of the insects through mature fruits is low, whereas at an international level there is no risk. Management practices, if implemented at marble size when pest attack begins, can regulate the pest. Moths take at least one month to complete each generation. Thus during fruiting season (of three months), the pests can be expected to complete at least three generations. Studies on how the moths survive up to the next season and their biological control are needed.

The present study shows that regions in other parts of India as well as South and Southeast Asia need to be vigilant of the spread of *Citripestis eutraphera*, perhaps through immature fruit movement. This further highlights the importance of stringent passenger bag screening and other quarantine measures between Port Blair and mainland India, both at sea and air ports of entry. There are many insects which are unique to the Andaman and Nicobar Islands not present in the mainland[16]. It is therefore in the interest of our economy and biodiversity conservation to strengthen quarantine. This is also vital for other fauna and flora, especially where two lands are separated by sea, because once introduced eradication is costly and difficult.

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Indian *Cycas* under severe threat

Cycads are an ancient group of plants which have survived three mass extinctions. They are dioecious, perennial, palm-like trees or shrubs with woody trunk above the ground or subterranean. They are a relict group of seed plants that evolved in the late Carboniferous or early Permian around 300 million years ago[1]. With the ever-increasing interest in cycad taxonomy over last two decades, the number of new species of cycad has increased significantly. At present around 340 species belonging to 10 genera in 3 families are found naturally in tropical and subtropical regions. They are distributed in at least 60 countries in South and North America, Africa, Asia and Australia[2–4]. All the surviving cycads are under threat due to various abiotic and biotic pressures. They are listed amongst the most threatened plant families in the world in the 1997 IUCN Red List of Threatened Plants[5]. Nearly 64% of cycads are threatened, which is the highest value of risk of extinction given to any group of organism[6,7].

Taxonomy of cycads had its origin in India. Van Rheede gave the first description of a cycad, 'Todda panna', the Malayalam name of *Cycas circinalis*. Linnaeus[8] used the illustrations of Van Rheede for naming the genus *Cycas*. In India, cycads are represented by only one genus, *Cycas*. Out of the 12 species (Table 1) of Indian *Cycas* reported so far, 5 species, viz. *Cycas andamanica*, *Cycas annaikalensis*, *Cycas indica*, *Cycas nayagarhensis* and *Cycas swamyi* have been described in the last 10 years[9–13]. They grow naturally in open forests or under canopy in the Western Ghats, Eastern Ghats, North East India, and Andaman and Nicobar Islands.

Indian cycads are extensively used as food, traditional medicine, cultural and religious rituals wherever they grow naturally. In South India, *Cycas* fronds are used to decorate temples and churches[14]. In remote areas of the Western and Eastern Ghats, seeds of *Cycas* are extensively used as food as an alternative for starch[15,16]. Male cones are used as pest repellent in Kerala and Odisha. In NE India, the young circinate leaves are commonly used as green vegetables and for making special dips and chutneys. Decoction of mature leaves is used to cure cystolithiasis and stomachache[17]. In urban areas, cycads are extensively grown in gardens as ornamental plant and the leaves are used in flower arrangement.

All the habitats of Indian *Cycas* species are threatened and have suffered severe reduction and degradation. These ever-increasing pressures are mainly due to clearing of forest, increase in human population, urbanization and unsustainable harvesting of seeds and male cones. Populations located at the vicinity of human settlements are more prone to anthropogenic activities, especially clearing of forest for agriculture. Illegal mining in forest areas and unsustainable harvesting of seeds are some of the main causes for reduction of cycad populations in the Eastern Ghats. All species of Indian *Cycas* are threatened (Table 1). Little