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Lepidopterans found aggressively devouring mango panicles: A paradigm shift in pest status

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ABSTRACT: In the recent past, mango inflorescences in India are being heavily attacked by multiple species of polyphagous caterpillars belonging to families *viz.,* Crambidae, Nolidae, Lymantridae, Tortricidae, Eutellidae, Hespiiridae, Pyralidae, Noctuidae *etc.* (Order: Lepidoptera). These caterpillars are causing severe damage to mango flowers than conventional pests like hoppers. The possible reasons for this observed change in the pest dynamics on mango flowers have been discussed in detail in this report.

Keywords: *Mangifera indica*, inflorescence, lepidopteran pests, herbivore interactions, climate change, insecticides

INTRODUCTION

Mango, *Mangifera indica* Linn (Family: Anacardaceae) is an extremely popular fruit in several countries. It originated in India ~2000 BC (Sauer Jonathan, 1993) and later spread to warmer regions viz., East Asia, Phillippines, Africa, Brazil (Gepts, 2009) *etc.* Mango inflorescence (= flower panicles; 200-3000 per tree) contains innumerable flowers (both males as well as hermaphrodites; 500 – 10,000 per panicle); of which only a few develop into fruits (2-3/ panicle) (Duke, 1993). Therefore, protecting the panicles from insect pests is very important. There are several species of insect pests' *viz.,* hoppers [*Idioscopus* spp, *Amritodus atkinsoni* Leth.], mealybugs [*Drosicha mangiferae* (Green), *Rastrococcus iceryoides* (Green)], thrips [*Scirtothrips dorsalis* Hood, *Haplothrips* sp., *Thrips palmi* Karny] that cause severe damage to mango inflorescence and can lead to total crop loss, if not checked in time (Verghese and Kamala Jayanthi, 1999, 2001). They predominantly damage inflorescence by sucking the sap (=sap feeders), resulting in browning, withering and shedding of flowers (Butani, 1979). Butani (1979) in his detailed pest status review on mango had mentioned that flower feeding caterpillars are 'not pests of economic importance' clearly indicating that previously, the pest pressure by the flower feeding caterpillars in mango was insignificant.

Earlier, Verghese and Kamala Jayanthi (1999) highlighted the potential dangers of the flower feeding caterpillars like *Eucrostus* sp. (Family: Geometridae); *Argyroploce aprobola?* Meyrick (Family: Eucosmidae); *Euproctis fraterna* Moore (Family: Lymantriidae) in mango. Further, this study hinted that if not managed, these caterpillars could cause flower drop up to 20-40%. But for this, no documentation on the incidence of caterpillars on mango inflorescence is available. In all possibilities, this study predicted niche shift of caterpillar complex in mango (from leaves to flowers). Further, the authors opined that these caterpillars are on the significant rise and can become serious than prioritized insect pests like inflorescence hoppers.

MATERIALS AND METHODS

During regular mango pest surveillance programs (2014-16), severe infestation by caterpillars on mango flower panicles was noticed in experimental orchards of the Indian Institute of Horticultural Research (IIHR), Hessaraghatta Lake PO, Bangalore (12°58'N; 77°35'E), Karnataka, India. Additional surveys during flowering season (26th February 2016 to 16th March 2016; a total of 13 observations was made) in rural areas of Bangalore across different villages (Fig. 1a) also revealed a high incidence of caterpillars. Observations were made on the number of caterpillars per panicle, species composition etc. Caterpillars were collected in polythene covers, brought to the laboratory, and identified to morphospecies (Fig 2). Each morphospecies was later digitised and reared to be an adult in the laboratory (14L:10D photo period, 27±1°C, 75±2% RH). For rearing, the caterpillars were placed individually in Petridishes (90 mm diameter, Tarsons, India) and provided with fresh mango flowers on daily basis until pupation. The pupae corresponding to the different morphospecies were kept separately till adult emergence. Adults were identified by Shashank P R. and voucher specimens were deposited at Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi.

To study the interaction among herbivores [hoppers (H) and caterpillars (CP)], mango flower panicles infested by both herbivores in an unsprayed mango orchard of IIHR were selected randomly and the number of hoppers present in different situations (absence and/or presence of caterpillars) were counted (n = 56). Observations were recorded on the number of hoppers per panicle. The hopper's response to caterpillar presence was studied, by releasing the caterpillar on panicle infested by hoppers with minimum disturbance. Periodical observations were recorded on hoppers/ panicle before and after the release of caterpillars (n = 18). Further, with in the panicle, the number of hoppers present on different rachises (on the rachis where hoppers coexist with caterpillars and on the rachis where only hoppers exist) was also counted (n = 80). Data sets were subjected to ANOVA using GraphPad Prism software (Ver. 6) for Mac OS X. To study the association between the herbivores, a 2 x 2 contingency table was prepared with χ^2 at $P = 0.05$ as test criterion (Southwood, 1978).

RESULTS AND DISCUSSION

A total of 22 morphospecies of caterpillars were found damaging mango flowers [9.85±1.38 (Mean±SE) per inflorescence; Range: 5.00 – 23.00] (Fig.2), of which, the richest families recorded were Crambidae, Nolidae, Lymantridae, Tortricidae, Eutellidae, Hespiiridae, Pyralidae and Noctuidae. Majority of the caterpillars were found to be polyphagous.

There were significant differences in the hopper numbers when they coexisted with caterpillars (n = 56; Mean±SE: 6.46± 0.45, P<0.0001) and occurred alone (n = 56; Mean±SE: 10.66± 0.52). The data on hopper count within the panicle also established the similar trend where the maximum number of hoppers were found on the rachis away from the caterpillars (n = 80; Mean±SE: 6.06±0.22, P<0.0001) than when they co-exist (Mean±SE: 0.79±0.11) (Fig.3b). When the caterpillars were introduced (@ one caterpillar per panicle) on to a hopper infested panicle, the pre-count (8.17±0.63) and post-count (1.67±0.44) of hoppers revealed that their numbers dwindled significantly upon caterpillar release (F = 71.63, *edf* = 34, P<0.0001) (Fig. 3c). The χ^2 showed a significant association (P = 0.05) between the herbivores. An odds ratio (<1.0) calculated from 2 x 2 contingency table indicated a negative association between the herbivores. Therefore, this data shows that the hoppers avoid sharing resources with another herbivore.

A clear surge in the pest status of the flower feeding caterpillars on mango is quite alarming and the possible reasons for the current upsurge are worth exploring. The recommended chemical management modules against hoppers in the past were dominated by IRAC Group 1A (Carbamates), 2A (Organochlorines), 1B (Organophosphates) that are acetylcholine esterase inhibitors, GABA-gated chloride channel antagonists and sodium channel modulators respectively with broad-spectrum activity as revealed by the historical data (1970's to 1990's) (Chari *et al.,* 1969; Sathianandan *et al.,* 1972; Singh et al, 1974; Gandhali *et al.,* 1975; Thontadarya *et al.,* 1978; Butani, 1979; Tandon and Lal, 1979; Shah et al., 1979; Yazdani and Mehto, 1980; Datar, 1985; Kumar et al., 1985; Pingle and Patil, 1988; Srivastava & Verghese, 1989; Mishra & Choudhary, 1996; Azizur Rahman and Kuldeep, 2007).

Later years of 1990s witnessed the introduction of newer insecticide groups for hopper management like imidacloprid a systemic neonicotinoid. Thereafter, mango hopper management modules have been over-dependent on this new molecule. Further, the advantages of imidacloprid like its efficacy at low concentrations i.e.,

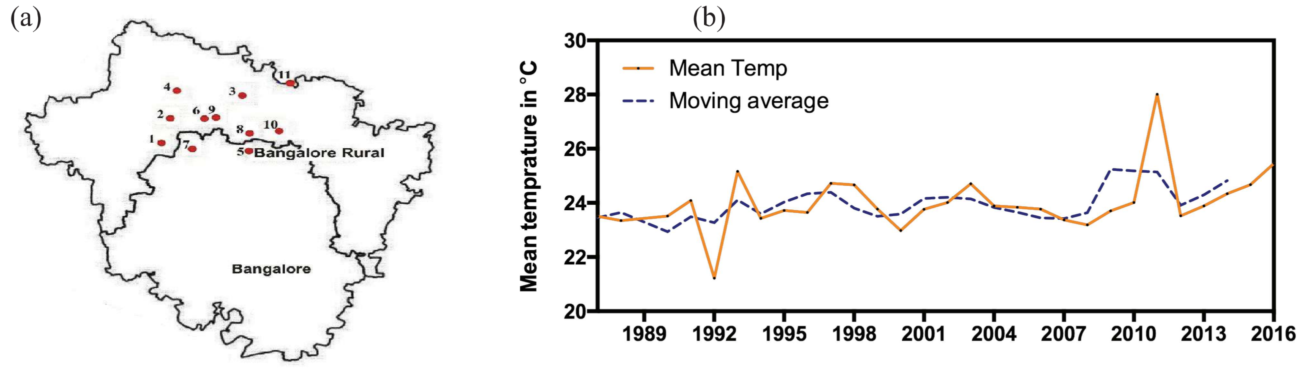

Fig 1. (a) Surveillance of mango inflorescence caterpillars in different areas of Karnataka (1-12; 1:Bandaihnapa lya,2:Gopalpura,3:Hospalya,4:Kodihalli,5:Haravallipalya,6:Kollarayanahalli,7:Silvipura, 8:Lingana-halli,9:Go llahalli,10:Biljaji,11:IIHR) (b) Temperature trend in the study area from 1987 to 2016

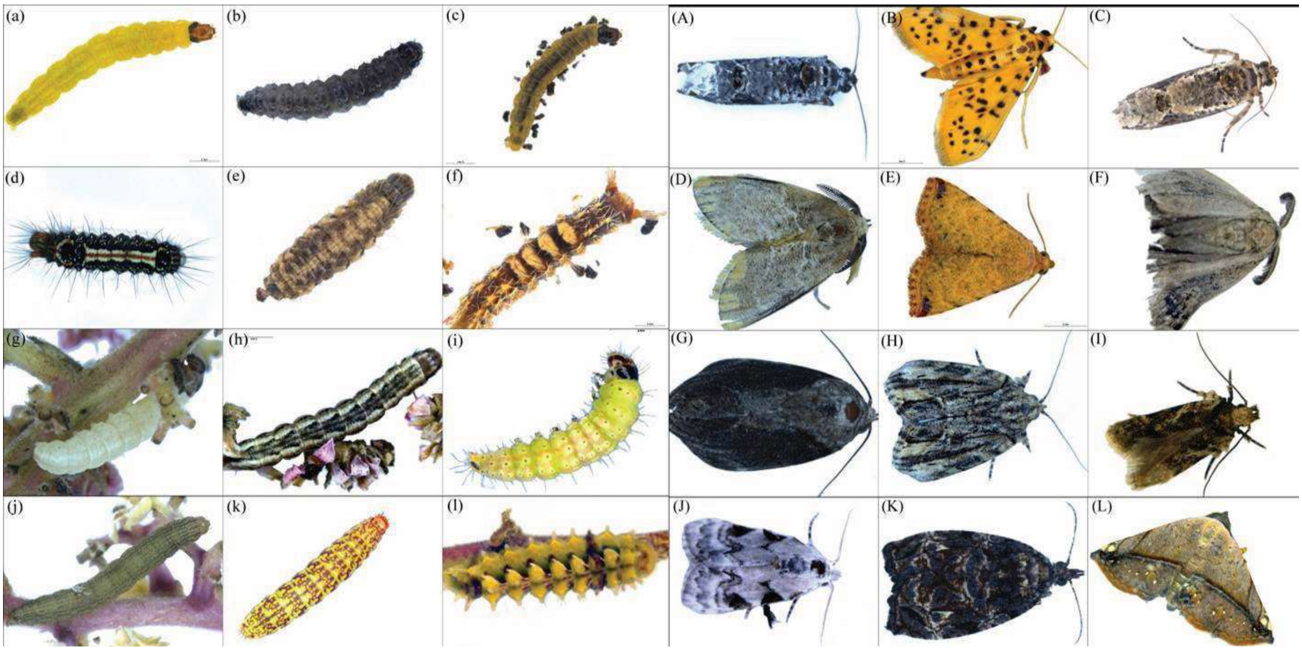

Fig.2. Selected morphospecies of lepidopterans found attacking mango inflorescence. This collection includes larvae (depicted in lower case, a-l) and adults (A-L); *Dudua aprobola* Meyrick, Family: Tortricidae (a,A); *Conogothes punctiferalis* (Guenee), Family: Crambidae (b,B); Genus, Sp indet, Family: Tortricidae (c,C); *Euproctis* sp, Family: Erebidae (d,D); *Autoba* sp, Family: Eribidae (e,E); *Olene mendosa* Hubner, Family: Lymantridae (f,F); Genus, Sp indet (g,G); *Nanaguna* spp, Family: Nolidae (h,H); Genus, Sp indet, Family: Gelechiidae (i,I); larva of *Penicillaria jocosatrix* Guenee, Family: Noctuidae (j); Genus, Sp indet, Family: Noctuidae (J); larva of *Chlumetia* spp, Family: Noctudiae (k); *Gatesclarkeana* sp, Family: Tortricidae (K); hairstreak caterpillar, Genus Sp indet, Family: Lycaenidae (l); *Autoba ?abrupta*, Family: Eribidae (L).

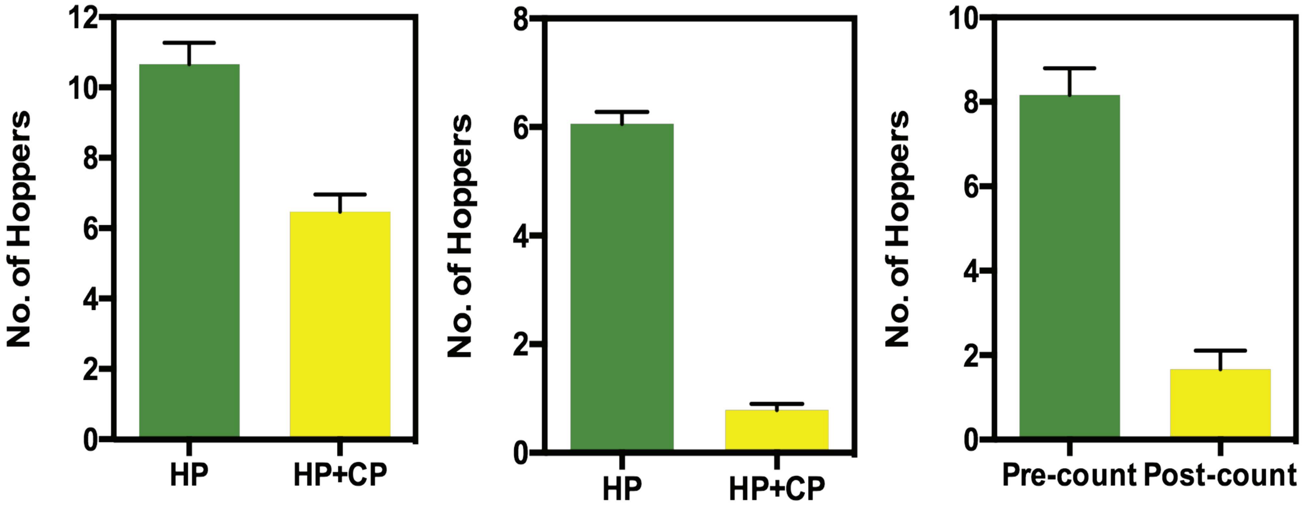

Fig 3. Mango hopper, *I. nitidulus* occurrence on mango panicles when exists alone (HP) and coexists with caterpillars (CP); (a) Between the panicles: significantly (*P*<0.0001) more numbers of hoppers/ panicle were noticed when caterpillars were absent (b) Within the panicles: significantly (*P*<0.0001) less numbers of hoppers were recorded on rachis where caterpillar present; (c) significantly (*P*<0.0001) less numbers of hoppers were noticed post-release of caterpillars on to panicles.

0.25 to 0.30 mL/ L and its comparative lower environment toxicity over other insecticides allowed it to replace more toxic, broad-spectrum carbamates, organochlorines, organophosphates (Anonymous, 2006; 2008). Thus, post-neonicotinoids entry would have allowed these caterpillars to establish on mango flowers. This change in pest status was indicated earlier (Verghese and Kamala Jayanthi, 1999). Most polyphagous lepidopteran species would have shifted to mango flowers as transients and established thereafter due to decline in pesticide pressure (Fig. 2). This fact corroborates with *Bt* cotton, where a reduction in pesticide usage during post-*Bt* era led to a flare-up of sap feeders like whiteflies (Anonymous, 2015). Thus, insecticide usage patterns impact crop pest scenario indicating the 'opportunistic survival' of secondary herbivores. This phenomenon of insecticide-based arthropod resurgence is usually attributed to a reduction in natural enemy populations and reduction in herbivore-herbivore competition as observed in the present study (Mark *et al.,* 1995). In mango, the differential effects of insecticidal application would have altered the structure of arthropod community associated with the crop as established in cole crops where the application of carbaryl led to aphid outbreaks coinciding with the absence of the herbivore competitors (Root and Skelsey, 1969).

Despite the fact that the role of competition among multiple species occupying the same niche has been of a long-standing interest in ecology, its effects remain poorly understood (Peers *et al.,* 2013). In the present study, mango hoppers and lepidopterans were used as models, to explore displacement of former by latter while feeding on mango panicles. Our data on herbivore interaction indicated that hoppers stayed away from caterpillars (Fig. 3) and an odds ratio calculated further endorsed their negative association.

Additionally, to dissect out the influence of climate change on the changing pest status in mango, the historic mean temperature data of the last couple of decades (1987 - 2016), for the study area was revisited (Fig. 1b). Insects' being poikilothermic, their body temperature depends on the surrounding environment and are most likely to respond to the changes in climate particularly to increased temperatures (Bjorkman and Niemela, 2015). As per IPCC (Intergovernmental Panel on Climate Change), the mean global temperatures increased by ~0.85^{o}C in the last 100 years and continue to increase under projected climate change scenario (IPCC, 2013). The mean temperature analysis of the study area (for the last ~35 years) indicated an upsurge in the temperature which is further confirmed by the moving average with an upward trend (Fig. 1b). The agricultural pest species respond to climate change faster than non-pest species, as anthropogenic factors such as land and pesticide use, play crucial role (Bjorkman and Niemela, 2015). Further, flowering in mango is significantly influenced by climatic conditions like photoperiodism and thermoperiodism (Duke, 1993). Whether flowering and pest status shifts in mango are related to changes in climate or changes in anthropogenic activities like pesticide usage as discussed earlier remains unclear. It is generally accepted that the damage by insects increases as a consequence of climate change, i.e. increasing temperatures primarily. But, proof-of-concept to elaborate this phenomenon in the present study is limited.

The shift in pest status of mango flowers is quite evident and lepidopteran pests are increasingly posing threat over major sap feeders like hoppers. This shift in pest status could be attributed to pesticide usage pattern alone or coupled with climate change. Nevertheless, this changing pest scenario on mango flowers complicates the pest management efforts stressing the need for a well-coordinated IPM strategy.

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REFERENCES

Verghese, A. and P.D. Kamala Jayanthi. 2001. Integrated pest management in fruits, In Pest Management in Horticultural Ecosystems, Capital Publishing Company, New Delhi. 1-23 pp.

Anonymous. 2006. Imidacloprid: Risk Characterization Document - Dietary and Drinking Water Exposure. California Environmental Protection Agency.

Anonymous. 2008. Conclusion regarding the peer review of the pesticide risk assessment of the active substance imidacloprid. European Food Safety Authority.

Anonymous. 2015. Black clouds over *Bt* cotton as whitefly runs amok. Available from: http://timesofindia.indiatimes.com/city/chandigarh/Black-clouds-over-BT-cotton-as-whitefly-runs-amok/articleshow/48880514.cms (9th April 2018)

Azizur Rahman, S.M. and Kuldeep. 2007. Mango hopper: Bioecology and Management-A review. *Agricultural Reviews*, **28**(1): 49-55.

Bjorkman, C. and P. Niemela. 2015. Climate Change and Insect Pests, CABI, 279 pp.

Butani, D.K. 1979. Insects and Fruits. Periodical Expert Book Agency, New Delhi.

Chari, M.S., S. N. Seshadri and H. K. Patel.1969. Control of mango hoppers. *Pesticides*, **3** (12): 33-35.

Datar, V.V. (1985) Synthetic pyrethroids in the control of mango hoppers (*Amritodus atkinsoni* Leth.). *Pesticides*, **19** (2): 13-14.

DUKE, J. A. 1993. CRC Handbook of Alternative Cash Crops, CRC Press, 548 pp.

Gandhali, D. N., L. M. Naik, and K. S. Darekar. 1975. Chemical control of mango hoppers, *Idioscopus clypealis* Leth. *Journal of Plantation Crops*, **3**(1): 9-10.

Gepts, P. 2009. "PLB143: Crop of the Day: Mango, *Mangifera indica*". *The evolution of crop plants*. Dept. of Plant Sciences, Sect. of Crop and Ecosystem Sciences, University of California, Davis. (Retrieved October 8, 2009)

IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Kumar, D., C. S. Roy, S. S. Yazdani, S. F. Hameed and Z. R. Khan (1985). Efficacy of some insecticides against hopper complex on mango (*Mangifera indica* L.). *Pesticides*, **19** (11): 42-43.

Mark. R., Hardin, Betty Benrey, Moshe Colt, William O Lamp, George K. Roderick and Pedro Barbosa. 1995. Arthropod pest resurgence: an overview of potential mechanisms. *Crop Protection*, **14**(1): 3-18.

Mishra, D.N. and A.K.S. Choudhary.1996. Field evaluation of some modern insecticides for the control of mango hopper, *Amritodus atkinsoni* Leth. *Environment and Ecology*, **14**: 299-300.

NICRA team of Mango Pest Surveillance. 2012. Manual for Mango Pest Surveillance. Jointly published by National Centre for Integrated Pest Management, New Delhi, ICAR Research Complex for Eastern Region, Research Centre, Ranchi, Central Research Institute for Dry land Agriculture, Hyderabad, and Central Institute for Subtropical Agriculture, Lucknow. 39 pp.

Peers, M.J.L., D. H. Thornton and D. L. Murray, D.L. 2013. Evidence for large-scale effects of competition: niche displacement in Canada lynx and bobcat. *Proceedings of the Royal Society of London B: Biological Sciences*, **280** (1773): 1-10.

Pingle, R.D. and S. P. Patil. 1988. Preliminary trial on chemical control of mango hoppers, (*A. atkinsoni*, *I. niveosparsus*) in lab. *Indian Journal of Agricultural Sciences*, **58**(6): 502-503.

Root, R. B. and J. J. Skelsey, 1969. Biotic factors involved in crucifier aphid outbreaks following insecticide application. Journal of Economic Entomology, **62**: 223-233.

Sathianandan, V. K., R. Bettai Gowder, and T. Santhanaraman.1972. Control of mango hoppers, *Idiocerus* spp. In Proceedings of 3rd International Symposium in Subtropical and Tropical Horticulture, 83-84 pp.

Sauer Jonathan, D. 1993. Historical geography of crop plants: a select roster. Boca Raton, CRC Press, 17 pp.

Shah, A.H., G. M. Patel, B. K. Patel. and R. C. Jhala, 1979. Field evaluation of some modern insecticides for the control of mango hopper, *Amritodus atkinsoni* Leth. *Pestology,* **2** (8): 26.

Singh, G., Ashok Kumar and P.K. Pathank. 1974. Studies on the efficiency of some insecticides against mango hopper, *Amritodus atkinsoni* (Leithierry). *Indian Journal of Horticulture,* **31**(3): 283-285.

Southwood, T. R. E. 1978. Ecological Methods. Univ. Oxford, UK, DOI. 10.1007/978-94-009-1225-0

Srivastava, R.P. and A. Verghese. 1989. Chemical control of mango leaf hopper, *Idioscopus clypealis* Lethierry. *Indian Journal of Entomology*, **51**(3): 358-359.

Tandon, P.L. and B. Lal (1979). Studies on the chemical control of the mango hopper, *Idioscopus clypealis* Lethierry. *International Pest Control,* **21**(1): 6-9.

Thontadarya, T.S., B. N. Viswanath and S. C. Hiremath (1978). Preliminary studies on the control of mango hoppers by stem injection with systemic insecticides, *Current Science*, **47**(11): 358.

Verghese, A. and P. D. Kamala Jayanthi, 1999. Lepidopteran pest complex on mango inflorescence. *Insect Environment*, **5**:51–52

Yazdani, S. S. and D. N. Mehto, 1980. A note on the control of mango hopper, *Amritodus atkinsoni* Leth. at Dholi. *Indian Journal of Entomology,* **42**(2): 475-476.

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