Electronic Repellent for Euducima Materna: a Fruit Piercer/Sucking moth

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***Abstract*—Moths of the genus *Eudocima* (=*Othreis*) are the dominant primary fruit piercers, accompanied by several secondary fruit feeders resulting in extensive damage to pomegranate and orange. The largely affected are for pomegranate in south and for orange in central India respectively. The damage is mostly observed during September to November. The earlier recommended methods such as catching the adult moths by hand net, smoking of the orchard in the evening, spraying the fruits with insecticides, baiting the adult moths with arsenic compounds, bagging of the fruits, deterring the moths by the bright light source and destroying the larval host plants were not effective in reducing the damage caused by these insects. The egg and larval parasitoids hold good promise for the suppression of fruit piercing moths damage. Enclosing whole orchard with nylon net also advisable. Bats act as a natural predator to these moths. Here in the paper the idea was to use the acoustic frequency of the bat to repel the moth. so, taking into account of this idea we have designed a circuit which radiates ultrasonic signals (above 120khz). Initial testing at laboratories for moth repellency is carried out. Response have been noted down.**

Keywords—Frequency repellent, pests, Electronic pest control

I. INTRODUCTION

Pomegranate (Punica granatum) is grown in tropical and subtropical regions of the world. The total area under cultivation of pomegranate in India is 107.00 thousand ha and production is around 743.00 thousand tons. Maharashtra is the leading producer of pomegranate followed by Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. The verity of pomegranates produced in indaia are, Ganesh, Bhagwa, Ruby, Arakta and Mridula. In India, pomegranate is commercially cultivated in Solapur, Sangli, Nasik, Ahmednagar, Pune, Dhule, Aurangabad, Satara, Osmanabad and Latur districts of Maharashtra. Apart from these, considerable amount of production is also form the districts like Vijayapura, Belgavi and Bagalkot districts of Karnataka and to a smaller extent in Gujarat, Andhra Pradesh and Tamil Nadu.

A. Indian Scenario

According to the data published by National Horticulture Board of India there is undersized decrease in the area of pomegranate cultivation in India from 109.00 thousand ha in 2008-09 to 107.00 thousand ha in 2010-11, similarly, the production has decreased from 807.00 thousand tons to 743.00 thousand tons during the same period. Table 1 presents the area, production and productivity of pomegranate in India,

Table. 1
Area, Production and Productivity of Pomegranate in India

Year	Area in 000' HA	Production in 000' MT	Productivity (MT/HA)
2008-09	109.00	807.00	7.40
2009-10	125.00	820.00	6.60
2010-11	107.00	743.00	6.90

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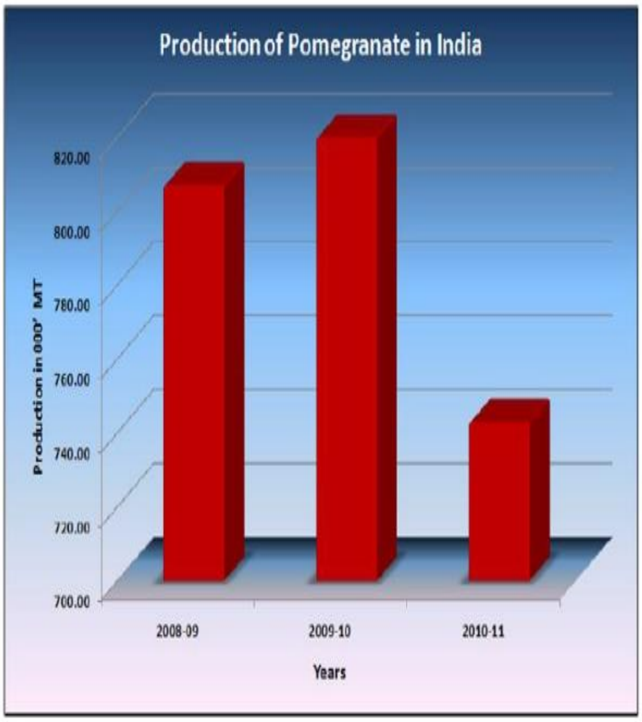

Fig. 1 Production of pomegranate over the last few years

Fig. 1 presents the graphical representation of the pomegranate production in India over the last few years. The total production of pomegranate is concentrated mainly in the Western Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Tamil Nadu and Rajasthan in India. Maharashtra is the leading State with 82-thousand-hectare area under pomegranate cultivation, followed by Karnataka and Gujarat with 13.6 thousand ha and 5.8 thousand ha respectively, Andhra Pradesh and Tamil Nadu stood at fourth and fifth position with. 2.8 and 0.5 thousand ha of pomegranate cultivation in India. Fig. 2, shows the area, production and productivity of leading Pomegranate growing states in India.

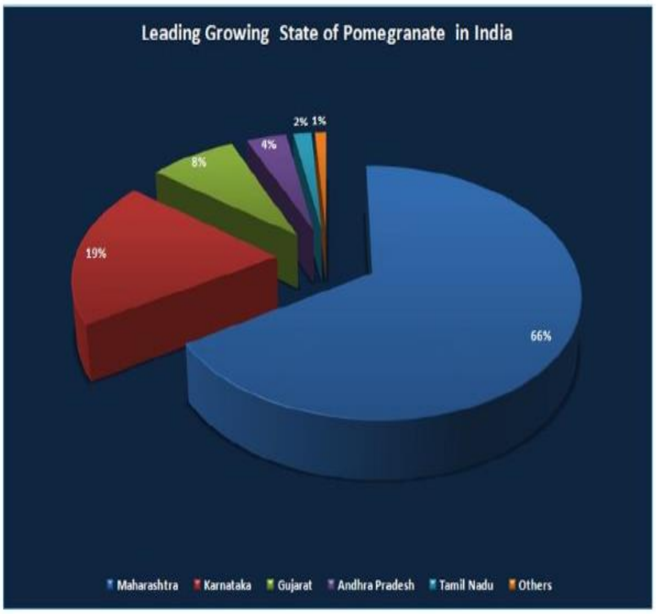

Fig. 2, Leading Pomegranate growing states in India.

Two species of fruit sucking moth E. Fullonia and E. Materna cause enormous damage. The attack takes place at all the times of fruit ripening & coauses a heavy loss to farmers. Though it attacks wide variety of commercially important fruits, it has become a serious pest on pomegranate in localized areas of Karnataka in India, where farmers have shown interest in commercial pomegranate plantations due to success in global export market. On an average, these moths damage 3 to 5 percent of fruits every year. The moths are nocturnal and may be seen flying about in orchards after dusk, especially during rainy seasons.

B. BIOLOGICAL BACKGROUND

The fruit sucking moth, *Eudocima (Othreis materna* (L.) is a polyphagous pest. The moth ca be found in India, Africa, Southeast Asia, Australia and the south Pacific. It feeds on a wide variety of commercially important fruits including pomegranate, citrus, guava, mango, papaya, carambola, grapes, litchi etc. Moths feed at night by penetrating the skin of the ripe or ripening fruit with their strong proboscis and sucks juice. Internal injury consists of a bruised dry area beneath the skin. Secondary rots develop at the punctured site [1]. Fermenting fruits are often visited and fed on by secondary-moth feeders taking advantage of the access hole drilled by this fruit sucking moth, *E. materna.* An individual moth would generally attack 0a fruit on a single night. Damaged fruits are completely unmarketable and must be removed at packing to avoid contamination of sound product. With current world emphasis on quality fruit for local consumption and export, this fruit sucking moth can cause heavy losses. *E. materna*, *E. homaena*, *A. flava* and *E.fullonia* of Ophiderinae and *A. janata*, *M. frugalis* of Catocalinae were dominant on pomegranate at Raichur and Bijapur (Karnataka). *Eudocima fullonia*, *E. materna* and *E. homaena* were the major fruit piercing moths on pomegranate in Karnataka [2]. According to a (1945) fruit piercing moths were found during the rainy season only, i.e. from the first week of July to the last week of September at Gwalior. The highest moth activity was observed during October of 1998 and 1999 at Raichur and Dharwad. When maximum damage to pomegranate and guava was done, the duration of egg, larval and pupal stages of *E. fullonia* as 3 4, 15 and 21 days, respectively in Madhya Pradesh on *Tinospora cordifolia* Miers.

C. Eudocima materna

The duration of egg, larval and pupal stages of *E. materna* reared on *T. cordifolia* was 3, 18 and 9 days, (Cherian and Sundaram, 1936), 8 10, 28 35 and 14 18 days (Ayyar, 1944), 3 4, 12 15 and 8 10 days (Sontakay,1944) and 3.5-4.0, 11.5-15.5, 12.5-14.0 days (Bhumannavar, 2000), respectively. Srivastava and Bogawat (1968) and Lolage and Khaire (1998) studied detailed biology of *E. materna* on *T.cordifolia*. Bhumannavar (2000) studied detailed biology on *T.cordifolia* and mentioned that *E. materna* larvae did not feed on other Menispermaceae. Mohite *et al.*, (2004) mentioned that at Nagpur, the period from the egg stage to adult death ranged from 35 to 52 days in males and 35 to 56 days in females of *E. materna*. Sevestopulo (1940) described the larval stages of *E. materna*. Hargreaves (1936) studied the biology of *E. materna* on *Rhigiocarya racemifera* Miers in Sierra Leone. In laboratory study, it was revealed that adult longevity, fecundity, oviposition period, larval period and pupal period of *E. materna* were inversely affected by elevated temperature of 33°C (Mohite *et al.*, 2005).

D. List of symptoms/signs

- Fruit - external feeding
- Fruit - lesions: black or brown
- Fruit - obvious exit hole
- Fruit - ooze
- Fruit - premature drop

Adults of E. fullonia feed on the juices of fruit by penetrating the skin or rind with a strong, barbed proboscis [3]. One or more neat, pinhole-sized holes are the first external signs of attack. Juice often weeps from the feeding holes, and can discolour the surrounding fruit. The damaged tissue beneath the skin tends to be disturbed, honeycombed and spongy. Fruit-rotting moulds, such as Oospora spp. and Fusarium spp., soon invade the wound causing rapid breakdown (and fermentation). In crops such as citrus, this is manifested as a large discoloured patch surrounding the feeding site. Fruit fall is common in some crops, particularly in citrus, and is an early symptom of fruit-piercing moth activity. Secondary sucking species frequently visit damaged fruit.

II. MOTH CONTROL

The various means attempted or proposed to control fruit-piercing moths have been discussed by Baptist (1944), Banziger (1982), Dodia et al. (1986), Waterhouse and Norris (1987), and Fay and Halfpapp (1991)
Selecting

A. Cultural Methods

Various cultural methods followed by the regional farmers are as follows:

a. The collection and destruction of rotting or fallen fruit may have some limited effect on E. Fullonia when populations are low, and will reduce the numbers of secondary moths.
b. Early harvest of fruit, particularly in outbreak years, will help to reduce damage levels. However, industry-imposed maturity standards may not permit such an approach.
c. Fay and Halfpapp (1993a) recommended that crops be planted in square blocks, rather than in a few long rows, as most fruit-piercing moth attacks occur along the outer edges of crops. This should limit the damage to fewer plants.
d. A trap or decoy crop which is known to be highly attractive to E. fullonia could be employed as a peripheral crop to dilute the number of moths penetrating to the more valued central crop [4].
e. Populations of E. Fullonia diminish seasonally in many areas, and this offers opportunities for the production of commodities in the absence of moth activity (Fay and Halfpapp, 1993b).
f. Where possible and practical, the removal of plants that are hosts of larvae within the vicinity of susceptible crops will reduce the incidence of fruit-piercing moth [5, 6].

B. Chemical Methods

Due to the variable regulations around (de-)registration of pesticides, we are for the moment not including any specific chemical control recommendations. For further information, we recommend you visit the following resources:
- EU pesticides database
- PAN pesticide database
- Your national pesticide guide

Impact : In those countries in which more than one species of Eudocima exist, it is difficult to stipulate the proportion of fruit lost to E. fullonia. In Maharashtra, India, Mote et al. (1991) reported up to 57% of pomegranate fruit suffered damage by fruit-piercing moths, including E. fullonia.

Failure to detect fruit-piercing moth damage at harvest or packing can result in sound fruit being contaminated by fermenting juices during shipment. Whole boxes or cartons of fruit may then be lost. The economic impact of fruit-piercing moths is often masked by the emphasis placed on fruit flies, some of which occasionally utilize fruit-piercing moth wounds for oviposition.

III. MODEL & DESIGN APPROACH FOR ELECTRONIC MOTH CONTROL

[7] Acoustic technology has been applied for many years in studies of insect communication and in the monitoring of calling-insect population levels, geographic distributions and species diversity, as well as in the detection of cryptic insects in soil, wood, container crops and stored products. There remains potential for using ultrasonic bat-cry signals to disrupt behavior of night-flying insects, but ultrasonic signals have little effect on insects that are not normally preyed upon by bats. Potential areas for growth in the use of acoustic technology in pest management include the production of signals that disrupt vibrational communication, particularly in the Hemiptera, and the development of control treatments that combine pheromones and precisely patterned sonic or vibrational signals. “Potential applications of acoustic or vibrational signals for trapping of hemipteran insects or behavioral manipulation of their communication, as well as for repelling ants or otherwise interfering with their colony maintenance activities have been considered but not yet implemented in field environments.”.

A. Block Diagram

Electronic moth repellent consists of solar panel, battery, sensor circuit, relay circuit, Arduino Uno, amplifier circuit and piezo tweeters.

a. Battery used to power up the device, charged either by solar panels or by ac supply. Here we are using 6V battery supply.
b. Sensor circuit is used to sense the day and night, since moths (E. Materna) are nocturnal attack fruits only during night. Hence, circuit is made to be active only during night by using LDR sensor.
c. Relay circuit is used to make automatic switching on and off of the device. Hence the output of the sensor circuit is interfaced with relay circuit.
d. Arduino Uno is used to generate ultrasonic frequency pulses. We are generating frequency of 250khz.The

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output is measured at pin 9 of the Arduino Uno board.

e. Power amplifier is used to amplify the signal generated by the Arduino Uno since the generated signal is weak. Darlington pairs are used for amplification.

f. Piezo tweeter is used to produce the ultra sonic sound generated by the Arduino Uno.

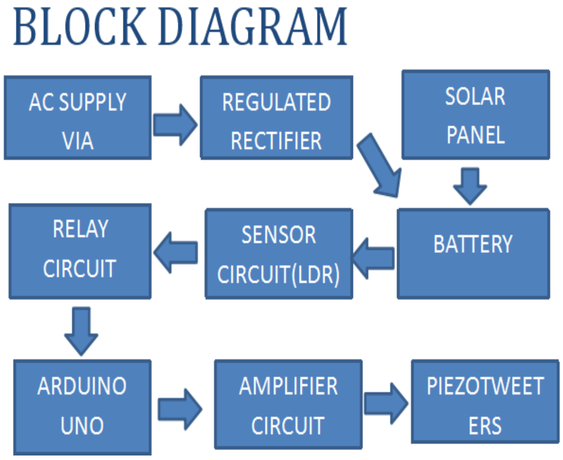

Fig. 3, Block diagram of the electronic moth repellent circuit.

IV. TESTING & RESULTS

A. Test setup

The test bench was set up at the University of Horticulture, Bagalkot, Karnataka, India. Test was conducted by taking 20 moths in a cage. In the presence of electronic moth repeller & the behavior of the moths was observed. At first the moths were made to settle in cage, then by maintaining the repeller at different distance and frequency the repellency of the moths was noted. The number of moths that gets disturbed or repelled was noted down and the percentage is calculated.

$$\text{Percentage of responding} = \frac{\text{Moths in flight} \times 100}{\text{Total moths}}$$

By using above formula, the percentage of responding of moths was calculated.


Fig. 4. Test set up for the observation and reppeling of the moths under test

The figure 4 shows the test set up for the moth repelleability/responsivity. The moths were allowed to settle first and then the repellent which produces the sound waves the frequency which will be required to repel the moths. Figure 4-6 presents the steps of the measurements. First the Moths are allowed to settle, then the electronic circuit of the moth repellant is activated and then the responding of the moths to the sound wave is noted down.


Fig 5. Repllant setup


Fig. 6, responsivity measurement of the moths

Fig. 7, presents the Testing of the soiund signal genrerated at the lab.

B. Results

Results obtained as the outcome of testing are:

Distance (feet)	Frequency (Khz)	Moths in flight	Percentage of moths responding(%)
5	100	-	-
	150	9	45
	200	13	65
	250	13	65
4	100	-	-
	150	12	60
	200	12	60
	250	17	85
3	100	6	30
	150	11	55
	200	10	20
	250	12	60
2	100	-	-
	150	11	55
	200	11	55
	250	12	60
1	100	8	40
	150	11	55
	200	7	35
	250	18	90

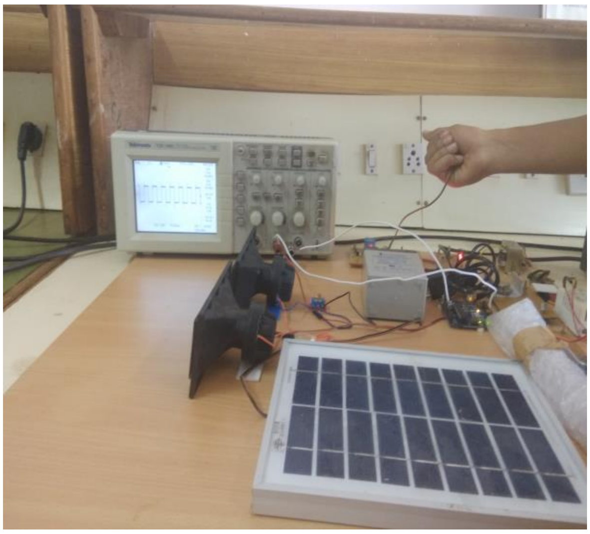

Fig. 7 Testing of the acoustic signal

V. CONCLUSION & FUTURE SCOPE

Electronic moth repellent has been successful in repelling fruit sucking moth, which in turn decreases the percentage of moths damaged by the mentioned fruit sucking moth. This will inturn increase the farmers economy. The device is easily programmable, compact and eco-friendly. Presenting the pulses at unpredictable intervals. The signal produced by the arduino is at the fixed interval of time. By using multiple frequency generation technique different duration of pulses can be generated. This will decrease the chance of adoptability of the moth. Making use of large solar panel to cover the entire field. Larger area can be covered using solar panel of larger dimensions. Moving the signal source or imparting apparent motion to the signal source, disrupt behaviour of night-flying insects. Interfacing the Arduino with GSM and IOT. The farmer uses his mobiles in order to switch on the device. The farmer can alter the frequency by using mobile.

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2. Mallikarjun C. J, M. Sc Entomology, College of Horticulture, Bagalkot, UHS Bagalkot, Karnataka, India

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