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Record of an epidemic outbreak of *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae) on *Avicennia marina* in the mangroves of Maharashtra, India

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Abstract
Hyblaea puera commonly known as the teak defoliator causes regular defoliation and seasonal outbreaks on the mangroves of Mumbai region particularly in Airoli creek of Navi Mumbai areas and in Gorai mangrove areas. This pest is prevalent during the post monsoon period and infesting *Avicennia marina* severely in Airoli and Gorai mangroves of Maharashtra State. The assessment intensity level of infestation revealed that epidemic level of infestation was recorded during the year 2019. Whereas in the year 2018 the intensity level was recorded as sporadic to moderate. Considering the severity of this pest, their host specificity, to assess the pest outbreak and to study the possible management practices to control the pest in mangrove ecosystem, this study was undertaken. Using of botanical biopesticide Hy-ACT at a concentration of 1% as foliar spray can control the pest in field condition causing 95% larval mortality in 48 hr. This study also revealed the natural occurrence of Nuclear Polyhedrosis Virus in the field and laboratory studies proved the confirmation of HpNPV on *H. puera*.

Keywords: *Hyblaea puera*, defoliator, outbreaks, intensity, biopesticide

Introduction
Avicennia marina is the most common and dominant species of mangroves available in all the mangrove areas in Maharashtra and found infested by the defoliating insect pests during the rainy season particularly during the post monsoon period. *Hyblaea puera* Cramer (Hyblaeidae: Lepidoptera) is a polyphagous pest infesting on many tree species including the mangroves species *Avicennia marina* and *A. officinalis*. Teak (*Tectona grandis*) was considered as the principal host for *H. puera*, therefore it was known as 'Teak defoliator' [1]. The biology of this pest was studied on different host plants but no information on the mangroves were available [2, 3]. Major outbreaks of this pest was reported during the post monsoon period during the year 2006 and 2009 on *A. marina* in Vikhroli mangroves area of Mumbai [4]. *H. puera* is widely distributed in Australian and Oriental regions like India, Sri Lanka and Malaysia and also present in South Africa and many parts of East Africa [5]. This insect was reported on teak in Nilambur of Kerala State regularly during April to early June at severe level of intensity, May to June in Coorg of Karnataka State and July in Bombay and Dehra Dun. In South India *H. puera* can complete at least 14 generations per year and 10 generations in Northern India [6]. Repeated and severe defoliation causes volume decrement of timber in grownup trees of Teak to the level of 4.5m^3 per ha. in a year [7]. Biannual pattern of infestation and outbreaks by different moths was reported on the mangroves in Brazil [8], but *H. puera* infestation was first recorded in Parana, Southern Brazil during the year 2016 [9]. Considering the importance and severity of this pest on mangroves a study was conducted to record the bionomics of this defoliating pest in mangrove ecosystem. During the surveys conducted to assess the pest problems of mangrove species in Airoli and Vashi creek revealed the epidemic level infestation of *H. puera* during the year 2019.

2. Material and Methods
Periodical survey at the mangrove areas at Airoli mangroves (N 19° 14´ 76.5" E 072° 98´ 43.9"), Ghansoil mangrove plantations (N 19° 11´ 50.9" E 072° 99´ 17.3"), and Gorai mangroves (N 19° 24´ 04.8" E 072° 80´ 08.8"), during the period 2018-2019 was undertaken to record the pest status of *H. puera*. The intensity of infestation was assessed based on the level of incidence of the insect pest and percentage of the damage/extent of damage caused.

Larvae collected from the field were reared in laboratory condition and studied the life cycle. Bioassay studies were conducted on the targeted pest in laboratory condition by using the biopesticide Hy-ACT (a product of the Institute of Forest Genetics and Tree Breeding, Coimbatore) with different concentrations (0.25, 0.50, 0.75 and 1%). For each concentration 20 larvae of 3rd instar stage were used for the experiment with five replications. Standardised the dosage percent for the application in field level experiments.

Confirmative tests were carried out by using the crude solution of Nuclear Polyhedrosis Virus (NPV) derived from the naturally infected larvae on the freshly reared larvae of *H. puera* in laboratory condition.

3. Result and Discussion

H. puera was observed as a seasonal and important pest infesting *A. marina* plants heavily during the rainy season particularly during the period from June to December. The intensity level of infestation was peak during the month of July to September (Fig.1 A). During the year 2018 the intensity level of attack was recorded as moderate (40% in August and September), where as in the year 2019 an epidemic level of infestation was recorded during the period from July to October (Graph 1) and total defoliation was recorded during the month of September and October. *H. puera* moths are small, with a wing span of 3 to 4cm. Forewing was greyish brown and the hind wings had black and orange-yellowish markings (Fig.1 D). The eggs were more or less elliptic and flat and laid singly near the veins on the lower side of the leaves. About 400-450 eggs were laid by a female moth on the leaves. During rearing of this moth in laboratory condition it laid eggs on the thin cloths. The young larva was greenish with a black head, but the body colour darkens on maturity to bluish black with black spec, bearing the setae. The under surface was lighter or olive green in colour. The full-grown larva was stout and fleshy, almost black or dark greyish green with faint longitudinal lines or black with a broad dorsal orange coloured band and lateral longitudinal white and black lines (Fig.1 C). They make a shelter by folding over a part of the leaf and spinning silk. The larva retreats from danger by passing through a hole to the other side of the leaf or by dropping on a silk thread. The pupation takes place on the leaf in a triangular leaf fold and also on the branches. The life cycle of the pest was completed within 28 to 35 days depending mainly on the climatic condition.

Though the pest generation occurs throughout the year, its population reaches peak during the period from June to September in different mangrove areas of Thane district of Maharashtra (Fig.1 B). The moths when reach a critical density in a particular location was found to migrate a minimum distance of 5 to 10 kms. Such migration facilitates exploitation of new food sources. Due to its continuous generation and short life cycle period the insect population increases enormously, which often leads to epidemic outbreak and complete denudation of *A. marina* plants. As far as the impact of defoliation was concerned, it doesn't result in mortality of plants.

Though the population dynamics of *H. puera* was studied on teak by different researchers in India no studies on the bionomics of this pest on mangroves. A botanical based biopesticide Hy-ACT was found to control the pest effectively both in laboratory as well in field condition. Among the different concentrations (0.25, 0.50, 0.75 and 1%) of the biopesticide tested, the concentration 1% was found very effective in controlling the pest caused 100 percent mortality in laboratory condition (Fig.1 E) and 95 percent mortality in field condition in 48 hr. (Graph.2) (Fig.1 F). Similar type of studies were carried out on *H. puera* by various researchers. Neemazal (Neem based product) of 30,40 and 50ppm caused 100% mortality of *H. puera* in laboratory condition [10]. The extract of *Pongamia pinnata*, *Nerium oleander* and *Thevetia nerifolia* were tested on *Corcyra cephalonica* and caused 80%, 86.6% and 88.3 % mortality respectively [11]. Parthenium extracts of 5% showed 13.3% mortality on *Eutecona machaeralis* at 24 hr. [12]. Extracts of *Parthenium hysterophorus* showed 100 percent mortality on the early instar larvae of *H. puera* in 48 hr. interval [13]. Extract of *Jatropha curcas* and *Azadirachta indica* were tested for their antifeedant property against the larvae of *Papilio demoleus* [14]. Twenty-five different isolates of an entomopathogenic fungus, *Metarhizium anisopliae* were tested for their efficacy against *H. puera* [15]. Studies were reported on the investigations and the effect of Nuclear Polyhedrosis Virus (NPV) on the teak defoliator in laboratory as well in field condition on teak [16]. Similar studies were reported as management of *H. puera*, involved mainly the use of HpNPV and few studies on using the biocontrol agents like *Bacillus thuringiensis*, *Beauveria bassiana* and some botanicals [17]. Biological control of the pests by using the NPV were also recognised as an effective biocontrol agent of the defoliator *H. puera*. Confirmative tests carried out by using the crude solution of NPVon the targeted pest *H. puera* proved positively and the Polyhedral inclusion bodies were observed under the microscope (Fig.1 G and H).

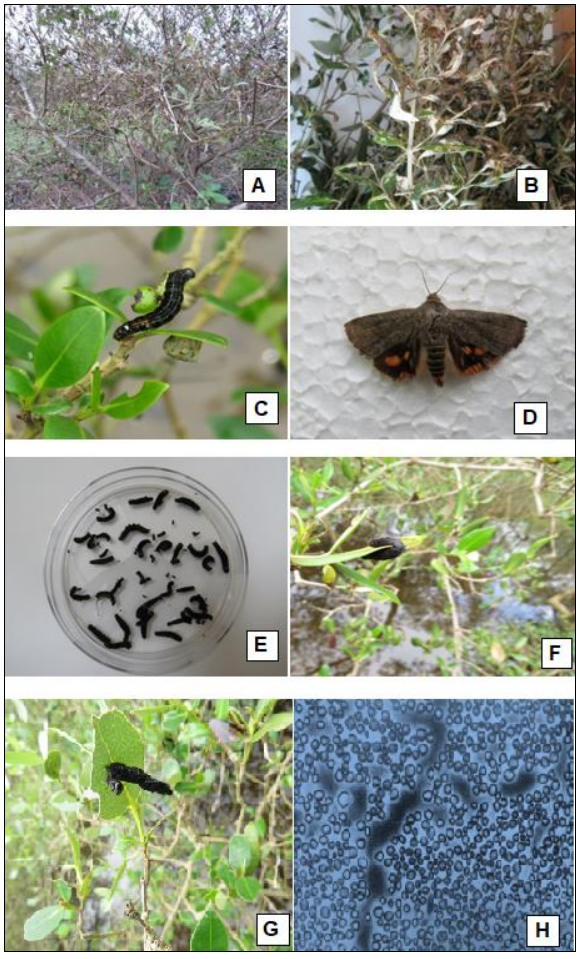

Fig 1: *Hyblaea puera* attack on *Avicennia marina* in Airoli

(A) Total defoliation of *A. marina* (B) Young *A. marina* plants infested by *H. puera* (C) III instar larva (D) Adult moth (E) Larval mortality of *H. puera* due to the effect of Hy-Act biopesticide in laboratory condition (F) Larval mortality in the field (G) NPV infected larva (H) Polyhedral inclusion bodies (PIB).

4. Conclusion

The present study finds and confirms that *H. puera* is a potential and harmful insect pest of *A. marina* in mangroves. The intensity of the pest incidence was severe in the year 2019 and total defoliation of *A. marina* was recorded in the study area at Airoli and Gorai mangroves during the months of September and October. Eco-friendly approaches such as biological control, application of botanical based biopesticides entomopathogenic fungi are considered as the best alternatives to chemical pesticides. Foliar spraying of the botanical biopesticide Hy-ACT at a concentration of 1% control the pest in field condition causing 95% larval mortality in 48hr. Further studies are required to see the possibility of using Nuclear Polyhedrosis Virus (NPV) in mangrove ecosystem to control *H. puera*. Integrated pest management, judiciously blending all available control methods with due consideration to economical viability and environmental safety is the best to keep the pest outbreak in control.

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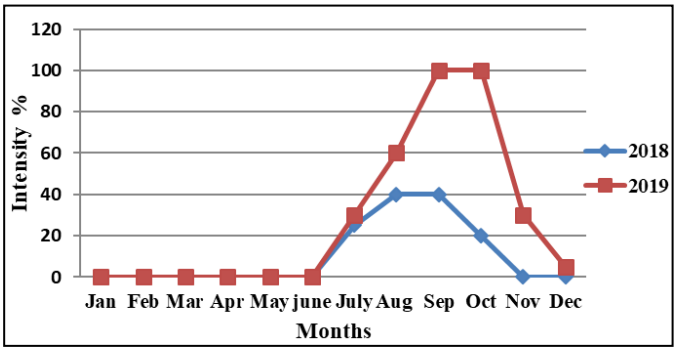
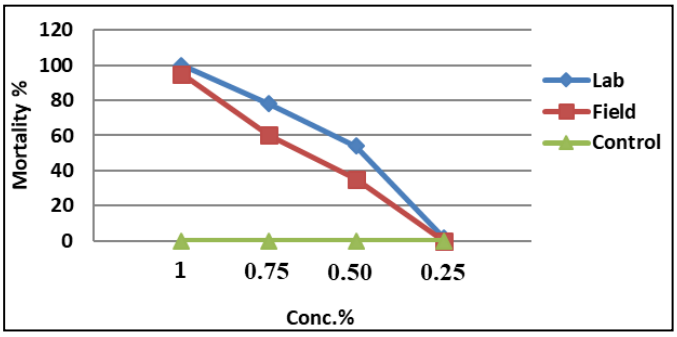


Graph 1: Intensity of *Hyblaea purea* on *Avicennia marina* during 2018 and 2019



Graph 2: Effect of different concentrations of Hy-Act Biopesticide on the larval mortality percentage of *H. puera* in lab and field condition in 48 hr.

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