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Adoretus duvauceli Blanchard (Coleoptera: Scarabaeidae): A new threat to ber plant (*Ziziphus mauritiana*) in eastern Uttar Pradesh, India

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Abstract
The present study reports, the first record of *Adoretus duvauceli* Blanchard as a serious pest of ber, *Ziziphus mauritiana* Lamarck from India. Studies were conducted during the *kharif* season at Varanasi and Mirzapur districts of eastern Uttar Pradesh and observed that about 40 per cent of the plants and about 80-100 per cent leaves of each of the plants were damaged by this leaf feeder. Critical observations revealed that adults of *A. duvauceli* voraciously fed on the leaves of ber mostly during night time. In case of severe infestations, entire chlorophyll of the leaves were eaten, leaving only mid-ribs and veins. The infested leaves became skeletonized and the whole tree rendered leafless. Amongst the abiotic parameters, temperature, relative humidity, evaporation and wind velocity had direct influence (91%) on distribution and abundance of *A. duvauceli* on ber, *Z. mauritiana*. The detailed studies on morphology, taxonomy, seasonal incidence etc. of this sporadic pest have been discussed in the paper.

Keywords: *Adoretus duvauceli,* Meteorological parameters, New threat, *Ziziphus mauritiana*

Animal husbandry, being an integral part of Indian agriculture, plays an important role in livelihood security and economic sustenance in many parts of the country. Livestock production is highly dependent on quality and quantity of fodder crops. However, Indian farmers are generally reluctant to put their lands solely underfodder crops due to their poor economic returns. Therefore, there is a need to develop some fodder based alternate land use systems which can provide employment, food and sustainable family income (Sharma, 2014). Among the fruit trees, ber, *Ziziphus mauritiana* Lamarck (family Rhamnaceae) is most suitable as they are widely spaced and their interspaces provide good scope of growing fodder crops. Moreover, due to annual pruning of ber trees, they can be trained for above ground spreading for growing of fodder crops in both *kharif* and *rabi* seasons (Sharma, 2014). It is considered as an important component in agrihorticultural system and social forestry as this crop provides very good remuneration to the growers. In the western part of our country particularly the arid dry regions and hortipasture system in Rajasthan, farmers prefer ber as they get sustained production (fruit, fodder and fuel wood) from both fruit trees and grasses/ fodder crops intercropped with ber for their livelstocks and indirectly, this system improves soil fertility, mitigates climate change, increases biodiversity (Kumar *et al*., 2015). The leaves of the ber is a highly nutritive fodder for animals as about 5.6% digestible crude protein and 49.7% total digestible nutrients are present in the leaves (Anonymous, 2018). This crop is presently gaining importance amongst the farmers owing to its wide adaptability and good returns under diverse agro-climatic conditions. However, this ber crop suffers considerably due to the attack of many insect-pests throughout its growth period. As many as 130 species of insect and non-insect pests of ber have been recorded in India among which only 22 have attained major pest status (Balikai *et al.,* 2008). Amongst the foliage feeders, chafer beetles, grey weevils, ber butterfly and hairy caterpillar are important sometimes causing serious damage to this crop. Chafers or scarab beetles are the harmful phytophagous beetles of various agricultural and horticultural crops, feeding mostly on leaves, flowers, fruits, roots and other parts of the plants (Bhattacharyya *et al*., 2017). Haldhar *et al*. (2016) from Rajasthan, India reported six species of chafer beetles *viz*., *Holotrichia consanguinea*, *Adoretus decanus*, *A. kanarensis*, *A. stoliezkae*, *A. pallens* and *A. versutus* (Coleoptera: Scarabaeidae) infesting ber crop in India.

Recently, serious incidence of a chafer beetle was observed in and around Varanasi and adjoining Mirzapur

districts of eastern Uttar Pradesh. About 40 per cent of the plants were found to be infested with 80-100 per cent of their leaves were devoured by this leaf feeder. Several locals also confirmed its incidence. This prompted to conduct a detailed study of this nefarious pest as practically no information is available about this pest from this region on ber as well as from the Indo-Gangetic plains of northern India.

The adult beetles were collected and brought to the biocontrol laboratory of the ICAR-Indian Institute of Vegetable Research, Varanasi, India. To confirm its taxonomic identity, the preserved specimens of adult beetles were sent to National Pusa Collection, Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi, India for taxonomic identification. Damage severity of the scarab beetles was recorded from the initiation of the incidence on ber leaves during the *kharif* season of 2017. Periodical data were recorded at weekly intervals and per cent damage was computed by the following formula:

$$\text{Leaf damage (\%)} = \frac{\text{Damaged leaves}}{\text{Total number of leaves}} \text{ X } 100$$

To confirm their feeding, individual adults, starved for six hours, were released in each petri dish (8.5 cm dia) and tender ber leaves were given for their feeding. All the petri dishes were kept under laboratory conditions at 27±1°C temperature and 70±5% relative humidity with 12:12 h light: dark photoperiod. After twelve hours, damage symptoms were noted from the leaves.

The data on weather parameters during the period of observations were collected from meteorological observatory located at ICAR-IIVR, Varanasi. The weather parameters considered were daily maximum temperature (°C), daily minimum temperature (°C), average daily temperature (°C), average day relative humidity (%) at 7.00 am and 2.00 pm, bright sun shine hour, evaporation (mm), rainfall (mm) and wind velocity (km/h). The growing degree day (GDD) was calculated by subtracting base temperatures (10°C) from average daily temperatures whereas heliothermal unit (HTU) was derived by multiplying GDD with bright sun shine hours. The cumulative value of weather parameters were calculated by adding everyday value since the date of sowing.

For development of model, all the independent variables were plotted against the dependent variable *i.e.,* per cent leaf damage. Since growing degree day and heliothermal unit are derived from the base temperatures, therefore, they were not considered for the final model development. The independent parameters which followed an exponential or power curve pattern were compared based on AIC (Akaike Information Criterion; Akaike, 1974) values. The AIC is expressed as:

$$AIC = -2ln\ (l(\hat{\theta})) + 2q$$

Where the model's likelihood *i.e.,* likelihood of the sample for the values estimated from the model parameters and q was the number of weather parameters estimated. A smaller value of AIC suggests a better model and thus exponential model was found the best suited in all the cases.Regression diagnostics were also conducted to validate the model. SAS software version 9.3 was used for statistical analysis following standard procedures.

The serious incidence of a scarab, as foliage feeder was observed in and around Varanasi region during July - September months. About 40 per cent of the plants were infested by this foliage feeder. The infested plants recorded about 80-100 per cent leaf damaged. Critical observation revealed that the foliage feeder voraciously fed on the leaves of ber mostly during night time. Unlike other foliage feeders, they completely devoured the mesophyll tissues along with both the epidermises resulting the irregular hollow patches on the leaves. Maximum cent per cent of leaves were devoured by this foliage feeder. In severe infestations, entire chlorophyll portions were being eaten, leaving only mid-ribs and veins. The infested leaves became sieve like structure and the whole tree rendered leafless (Fig 2). Several local farmers visiting the institute were also reported the same problem. Since during the daytime (6.00 am to 6.00 pm) no pest could be recorded on the plants, observations were made during evening hour (6.00 pm) onwards till mid-night (12.00 am) at one hour interval each. During the observations, it was confirmed that the insect was crepuscular as maximum numbers of beetles (2.23) per leaf was recorded during immediately after sunset. During this period medium sized light brownish black coloured beetles were found in gregarious on feeding on the tender leaves of ber. The adult beetles were observed to colonize ber plants at dusk, with initiation of beetle colonization 24.5±2.45 minutes after sunset, with the earliest observed beetle colonization occurring 13.45 minutes after sunset during first week of August. After sunset, up to one hour it aggregated maximum and thereafter maintained the almost same population. When searched in the soil, adult beetles were observed to emerge from the soil clumps and debrises.

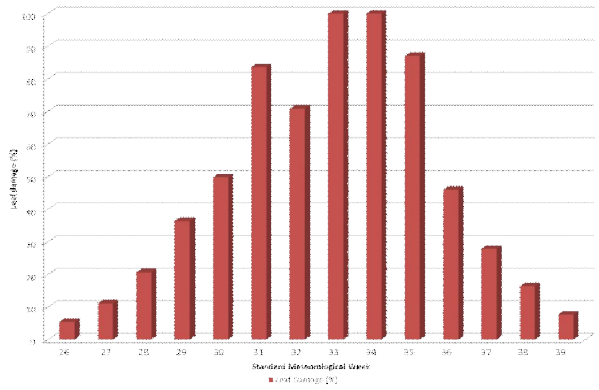

Fig 1. Seasonal damage potential of *A. duvauceli* on ber under Varanasi and Mirzapur conditions

The adult beetle was identified as *Adoretus duvauceli* Blanchard (Coleoptera: Scarabaeidae) (Fig 3) by the following diagnostic characters as described by Arrow (1917) body elongated rather depressed, brownish black in colour, evenly clothed with decumbent grey setae, pronotum short, elytral clothing not dense and bears tuft of minute white hair at apical callus, front tibia with three equidistant teeth, tarsal claw unequal, longer claw with cleft at middle and hind legs.

Fig 2. Ber leaves severely damaged by *A. duvauceli*

To confirm the feeding habits and host plants of this pest, individual adults were starved for six hours and released in each petri dishes (8.5 cm dia) and tender ber leaves were given for their feeding. All the petri dishes were kept under laboratory conditions at 27±1°C temperature and 70±5% relative humidity with 12:12 h light:dark photoperiod. After twelve hours, similar damaged symptoms were noted from the leaves thus confirming the host plant of this scarab beetle (Fig 4). Under north Indian conditions, ber plants bloom during September-October months with fruits ready to mature during February-March. Serious defoliation during August-September by this univoltaine insect not only delays the average fruiting period, but also drastically reduces the fruit bearing capacity of the plants as maximum photo-synthates of the plants are diverted to recoup its vegetative growth.

Field incidence of *A.duvauceli* was recorded from the twenty sixth standard meteorological week (SMW) (*i.e.,* last week of June) with 5.49% leaf damage, coinciding with the onset of monsoon, which gradually increased and reached 83.59% leaf damage during 31st SMW. It is also evident that all the leaves were damaged during 33rd and 34th SMW *i.e.,* third and fourth weeks of August (Fig 1). However, September onwards damage gradually decreased and only 7.63% leaf damage was recorded during last week of September (39th SMW) coinciding with receding monsoon in the region.

It was observed that maximum, minimum and average temperature had positive and significant correlation with the leaf damage and the corresponding correlation co-efficient (r) values were 0.626, 0.580, 0.623 respectively (Table 1). Similar observation was also noted with growing degree day (r=0.623). Relative humidity at 7:00 am and 2:00 pm had positive but non significant effect on scarab bettle damage (r= 0.181 and 0.203). Halder *et al.* (2017a-b) from Varanasi reported increase in *Diaphania indica* (Saunders) and *Nesidiocoris cruentatus* (Ballard) on other crops associated with period of high temperature. Singh and Singh (1993) from Varanasi also reported increase in red spider mite, *Tetranychus cinnabarinus* (Boisd) population and had strong positive correlation with prevalent high temperature.

Table 1. Correlation coefficient (r) of incidence of *A.duvauceli* with abiotic factors

Abiotic parameters	Correlation coefficient
Maximum temperature (T_{max})	0.626*
Minimum temperature (T_{min})	0.580*
Average temperature (T_{mean})	0.623*
Growing degree day (GDD)	0.623*
Relative humidity at 7 am (RH_I)	0.181
Relative humidity at 2 pm (RH_{II})	0.203
Rainfall (RF)	–0.011
Sunshine hours (BSS)	–0.126
Heliothermal unit (HTU)	–0.029
Evaporation (EP)	–0.333
Wind velocity (WV)	–0.207

*P<0.05 (2-tailed)

In contrast, rainfall, evaporation, wind velocity as well as wind speed had negative correlations with pest incidence but correlations were non-significant. Norris *et al.* (2002) recorded that rainfall significantly decreased the number of thrips remaining on the plants and as number of rainy

days increased, the numbers of thrips on the plants decreased and the majority of thrips were washed off the plants within 30 minutes. Earlier Halder *et al*. (2017b) also observed rainfall, wind speed and evaporation had negative correlations with the abundance of *N. cruentatus*.

Fig 3. An adult *A. duvauceli*

The stepwise forward selection method of model fitting was followed which begins with no variables in the model and then variables are added one by one to the model, and the F statistic for a variable to be added must be significant with improvement in coefficient of determination (R^2) of the model. The model thus obtained is given below:

$$Y = -1068.66 - 1140.11T_{max} - 1.175RH_{II} - 29.40EP - 1157.40\ T_{min} - 18.81WV + 4.45RH_{I} - 2265.94\ T_{mean}$$

Where Y is the per cent leaf damage. It was evident that the temperature, relative humidity, evaporation and wind velocity had direct influence (91%) on distribution and abundance of *A. duvauceli* on *Z. mauritiana*.

Fig 4. Ber leaves eaten by *A. duvauceli*

Damage to the leaves of different fruit crops by chafer beetle, *A. duvauceli* were reported earier from northern and southern India (Singh, 1964; Mani *et al*., 2014). But there was no report about the incidence of this chafer beetle as a foliage feeder of *Ziziphus mauritiana* from India. Therefore, to the best of our knowledge, this study constitutes the first record of *A. duvauceli* as a serious pest of ber from India.

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