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Biodiversity of insect pest complex infesting okra [*Abelmoschus esculentus*] in Tripura, N.E. India

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Abstract
Field experiments were conducted to study the biodiversity of insect pest species infesting okra in Tripura during two seasons viz, summer (April to July, 2016) and winter (October, 2016 to January, 2017). A total of twenty eight insect pest species belonging to 6 orders were found to infest this crop. Maximum number of species were belonging to Hemiptera (12 nos.) followed by Lepidoptera (9 nos.) and Coleoptera (4 nos.). The Shannon and Wiener diversity index (*H'*) during summer and winter season for the insect pest complex of okra was calculated as 1.01 and 0.91, respectively. The Simpson's diversity index (*D*) during summer and winter season was calculated as 0.14 and 0.19, respectively. These two indices for summer and winter season were more or less equal and exhibited a similar diversification. Similarly, Species Richness (7.31 and 7.49) and Species Evenness (0.71 and 0.64) during summer and winter season were more or less equal. However, by number the Leaf hopper (*Amrasca biguttula biguttula*), Leaf beetle (*Podagrica* sp.), Blister beetle (*Mylabris pustulata*) and Leaf folder (*Syllepte derogata*) were more abundant in the field during summer season where as, Leaf hopper (*Amrasca biguttula biguttula*), Aphid (*Aphis gossypii*), White fly (*Bemisia tabaci*) and Leaf folder (*Syllepte derogata*) were more abundant during winter season. However, during Summer season Blister beetle (*Mylabris pustulata*), Leaf beetle (*Podagrica* sp.) and Red cotton bug (*Dysdercus cingulatus*) were found to be major pests causing considerable damage whereas, during winter season Shoot and fruit borer (*Earias vittella*) was found to be the major pest.

Keywords: Okra, pest complex, biodiversity, Tripura, North East India

1. Introduction
Okra (*Abelmoschus esculentus* L. Moench, Family- Malvaceae), commonly known as *Bhindi* or *Ladies finger* is one of the most popular and commercially cultivated vegetable crops in India. It is mainly cultivated to produce the fruits that are consumed as a vegetable in a variety of ways. Okra is a rich source of carbohydrate, protein, fats, vitamins and minerals [1]. It is one of the major vegetable crops being widely grown throughout the year by the farmers of Tripura. Incidences of many insect pests on okra have been reported by many workers from different parts of the Country and some of which are responsible for considerable yield loss [7, 9, 11, 17]. However, insects, occupying vital positions in food webs, play an important role in maintaining ecological balance. Moreover, the species diversity of insects and their pest status varies from region to region with the variation in agro climatic conditions. Before an intelligent decision can be made about management of the insect pests, it is necessary to be able to properly identify which species of insects are major pests. Information on the occurrence of pests of okra in Tripura is lacking. So the present work was carried out to study the biodiversity of insect pest complex infesting Okra in this state.

2. Materials and Methods
The experiment was conducted in the experimental farm of College of Agriculture, Lembucherra, Tripura during two seasons viz., summer season (April to July, 2016) and winter season (October, 2016 to January, 2017).

2.1 Crop studied: The seeds of the okra variety NS 810 were sown in the 1st week of April for the summer crop and in the 1st week of October for the winter crop. The crop was grown following all standard agronomic practices excepting plant protection measures.

2.2 Method of observation: Insect pests occurring on Okra plants were observed at weekly intervals from 20 randomly selected plants from seedling stage to maturity of the crop through Plant Inspection Method (PIM).

2.3 Grouping of insect pests: Recorded insect species were categorized as major and minor pests on the basis of their incidence pattern. Insects which infested the crop in considerable numbers and were responsible for considerable damage with prominent damage symptoms like severe defoliation, growth retardation or damage to economic plant parts i.e. flowers and fruits (more than 5% damage) were considered as major pests. Insects which were encountered in a small number or which did not produce any prominent damage symptom or did not cause any substantial damage (less than 5%) were designated as minor pests.

2.4 Statistical analysis

Measurement of Relative abundance: To measure the percentage of individuals of a particular species over all the species following formula was used:

$$RA = \frac{n_i}{N} \times 100$$

Where,
R A= Relative abundance
n_i = Total number of individuals in the particular sample / species
N = Total population of all the species

Measurement of Biodiversity indices

Biological diversity studies use diversity indices as indicators. Following formulae were used to calculate the diversity indices.

Simpson index

$$D = \frac{\sum_{i=1}^{s} n_i (n_i-1)}{N (N-1)}$$

Where,
D = Simpson index
n_i = Total number of individuals in the particular sample / species
N = Total population of all the species

Shannon - Wiener index

$$H' = -\sum_{i=1}^{s}\left[\left\{\frac{n_i}{N}\right\} \times \log \left\{\frac{n_i}{N}\right\}\right]$$

Where,
H' = Shannon - Wiener index
n_i = Total number of individuals in the particular sample / species
N = Total population of all the species

Species evenness

$$J = \frac{H'}{\log S}$$

Where,
J = species evenness
H' = Shannon - Wiener index
S = Number of species in the community

Species richness

$$R = \frac{S - 1}{\log N}$$

Where,
R = Species richness
S = Number of species in the community
N = Total population of all the species

3. Results and Discussion

Insect pest species recorded in Okra crop during present study are presented in Table 1. A total of 28 insect pests belonging to 6 orders and 20 families were recorded. Among these, the maximum number of species were belonging to Order Hemiptera (12 species under 10 families) followed by Lepidoptera (9 species under 4 families) and Coleoptera (4 species under 3 families). Remaining three orders namely, Diptera, Orthoptera and Thysanoptera were represented by one species each. Relative abundance of insect pests belonging to different orders is shown in Fig.1. During summer, 2016 a total of 3613 individuals belonging to 27 species under 6 orders were collected from 240 randomly selected plants during 12 weeks of crop period. By number the Leaf hopper (*Amrasca biguttula biguttula*), leaf beetle (*Podagrica* sp.), blister beetle (*Mylabris pustulata*) and Leaf folder (*Syllepte derogata*) were more abundant in the field during the summer season with 23.64%, 19.13%, 15.50% and 8.86% relative abundance, respectively. However, during this season Blister beetle (*Mylabris pustulata*), Leaf beetle (*Podagrica* sp.) and Red cotton bug (*Dysdercus cingulatus*) were found to be major pests causing considerable damage. Adults of blister beetle were recorded to voraciously feed on flower buds and flowers hampering fruit setting. Both adults and nymphs of red cotton bug were found to infest the leaves, shoots and fruits and as a result of their feeding of sap the fruits were deformed with the development of some characteristic markings on the same making it unmarketable. Adults of Leaf beetle (*Podagrica* sp.) were recorded to appear in large number feeding on leaves making numerous holes on the infested leaves leading to reduced photosynthesis activity and growth retardation of the plants. Earlier, Flea beetle, *Podogrica bowringi* Baly was reported as the major pest on okra in Uttarkashi district of Uttaranchal [12]. Leaf beetle and blister beetle were reported as some of the key pests of okra causing significant crop damage at Kalimpong, West Bengal [14]. Blister beetle and Red cotton bug were reported as major pest out of 11 insects and 1 mite pest infesting okra in Mizoram [3]. Major pest status of insect pests as recorded in these two studies [14, 3] in April sown a crop of okra are in agreement with the present findings. Blister beetle, red cotton bug and Shoot and fruit borer have earlier been reported to be some of the major pests of Okra [7, 17]. Earlier, Chakraborty *et al*. [5] and Pal and Satpathi [14] also studied the biodiversity of insects in okra ecosystem in Karaikal, U. T. of Puducherry and Kalimpong, West Bengal, respectively. Both of these studies recorded Hemipteran herbivores as the most abundant and diverse insect group in okra ecosystem which is in agreement with the present study. However, Lepidoptera was recorded as the second most diverse insect group during the present study which does not corroborate with the earlier two works as both of these recorded Coleoptera as the second most diverse group.

During winter, 2016-17 a total of 2955 individuals belonging to 27 insect species under 6 orders were collected from 240 randomly selected plants during 12 months of crop period. By number, Leaf hopper (*Amrasca biguttula biguttula*), Aphid (*Aphis gossypii*), White fly (*Bemisia tabaci*) and Leaf folder (*Syllepte derogata*) were more abundant during this season with 36.72%, 14.25%, 13.71% and 8.46% relative abundance, respectively. According to Anitha and Nandihalli [2] the sucking pests *viz.*, aphid (*Aphis gossypii*) leafhopper (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*) and mite (*Tetranychus* sp.) are of regular occurrence and cause considerable damage in okra. However, during this season of present study, only one pest i.e. Shoot and fruit borer (*Earias vittella*) was recorded as major pest. The larvae bored the tender shoot during the vegetative stage of the crop resulting in drooping and drying of infested shoots hampering growth of the plants. During the reproductive stage of the crop the larvae bored into the fruits feeding on inner contents making them deformed in shape and unfit for consumption. This finding is in agreement with Gautam *et al.* [10]. Earlier, many studies have recorded this pest as one of the major pest infesting okra causing considerable yield loss [6-8, 15, 16]. However, its occurrence was not recorded in April sown crop during the present study and this is in conformity with Pal and Satpathi [14] and Boopathi, *et al.* [3] who also could not record *Earias vittella* in April sown okra crop in North Eastern hilly areas of India. Though whitefly, aphid and leaf hopper were relatively abundant in one or both the seasons but their population level was not sufficient to produce any prominent damage symptoms and hence they were considered as of minor significance. All other insect pests recorded were of minor significance. Dhamdhere *et al*. [7] reported 13 insect and non-insect pests species attacking okra at various stages of crop growth, the major being *A. biguttula biguttula*, *B. tabaci*, *S. derogata*, *Mylabris* spp., *D. koenigii* and *E. vittella*. Among the insect pests recorded infesting okra during the present study, *Bemisia tabaci*, *Aphis gossypii*, *Phenacoccus solenopsis*, *Nezara viridula*, *Ricania speculum*, *Leptocentrus taurus*, *Cletus punctiger*, *Helicoverpa armigera and Mylabris pustulata* have earlier been reported to infest Pigeon pea in Tripura [13].

The Shannon and Wiener diversity index (*H'*) during summer and winter season for the insect pest complex of okra was calculated as 1.01 and 0.91, respectively indicating almost similar diversification during the two seasons. The Simpson's diversity index (*D*) during summer and winter season was calculated as 0.14 and 0.19, respectively which were more or less equal and indicate a high degree of diversity among insect pest species in Okra ecosystem during both the seasons. Similarly, Species Richness (7.31 and 7.49) and Species Evenness (0.71 and 0.64) during summer and winter season were more or less equal.

4. Conclusion

It is, therefore, evident from the present study that a considerably large number of insect pest species infest Okra crop grown in this state and estimated values of biodiversity indices during two different seasons viz., summer and winter were more or less equal. However, seasonal variations in relative abundance as well as pest status of the insect species are observed. It is also evident from this study that mere occurrence of pest species with comparatively higher percent of relative abundance is not sufficient for the pest to be considered as major one. Rather, some species with relatively lower population frequency may appear with major pest status depending on the nature of damage and plant parts they infest as in case of Leaf beetle, Blister beetle, Red cotton bug and Shoot and fruit borer which need primary focus for formulating effective pest management strategy.

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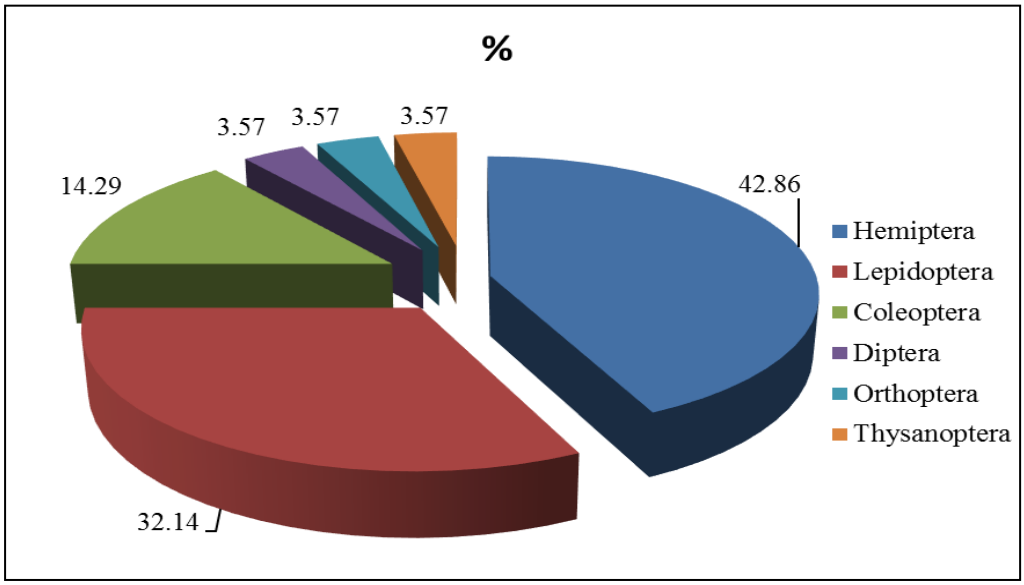

Fig 1: Relative abundance of insect pests belonging to different orders.

Table 2: Diversity, evenness and richness of insect pest complex in Okra during two seasons:

Season	No. of Species	Total no. of individuals	Shannon-Wiener index	Simpson's Index	Species Evenness	Species Richness
Summer, 2016	27	3613	1.01	0.14	0.71	7.31
Winter, 2016-17	27	2955	0.91	0.19	0.64	7.49

Table 1: Insect pest complex associated with Okra in Tripura:

Sl. No.	Order and Family	Common name	Scientific name	Plant parts infested	Relative abundance		Pest status	
					Summer, 2016	Winter, 2016-17	Summer, 2016	Winter, 2016-17
A	**Hemiptera**							
1	Cicadellidae	Okra leafhopper	*Amrasca biguttula biguttula* (Ishida)	Leaf	23.64	36.72	Minor	Minor
2	Cicadellidae	Sharpshooter leafhoppers	*Bothrogonia albidicans* (Walker)	Leaf	0.11	0.07	Minor	Minor
3	Aleyrodidae	White fly	*Bemisia tabaci* (Gennadius)	Leaf	6.20	13.71	Minor	Minor
4	Aphididae	Cotton aphid	*Aphis gossypii* (Glover)	Leaf, Flower buds, Flowers	7.33	14.25	Minor	Minor
5	Pyrrhocoridae	Red Cotton Bug	*Dysdercus cingulatus* (Fabricius)	Leaf, shoot and Fruit	5.40	1.35	Major	Minor
6	Pseudococcidae	Cotton mealybug	*Phenacoccus solenopsis* (Tinsley)	Leaf, fruit	2.91	4.37	Minor	Minor
7	Pentatomidae	Green stink bug	*Nezara viridula* (Linnaeus)	Leaf, shoot and fruit	0.42	0.14	Minor	Minor
8	Pentatomidae	Shield bug	*Menida histrio* (Fabricius)	Buds, fruits	0.89	0.14	Minor	Minor
9	Ricaniidae	Black leafhopper	*Ricania speculum* (Walker)	Leaf, stem	0.33	0.64	Minor	Minor
10	Membracidae	Cow bug	*Leptocentrus taurus* (Fabricius)	Leaf, stem	0.64	0.88	Minor	Minor
11	Coreidae	Coreid bud	*Cletus punctiger* (Dallas)	Leaf	0.42	0.24	Minor	Minor
12	Rhopalidae	Scentless plant bug	*Liorhyssus rubicundus* (Signoret)	Leaves and buds	0.55	0.41	Minor	Minor
B	**Lepidoptera**							
13	Noctuidae	Cotton semilooper	*Anomis flava* (Fabricius)	Leaf	0.39	0.20	Minor	Minor
14	Noctuidae	*Semilooper*	*Anomis fulvida* (Guenee)	Leaf	0.22	0.10	Minor	Minor
15	Noctuidae	American boll worm	*Helicoverpa armigera* (Hübner)	Fruit	0.69	1.12	Minor	Minor
16	Noctuidae	Tobacco caterpillar	*Spodoptera litura* (Fabricius)	Leaf	0.17	0.30	Minor	Minor
17	Nolidae	Cream drab	*Xanthodes albago* (Fabricius)	Leaf	0.14	0.10	Minor	Minor
18	Nolidae	Transverse moth	*Xanthodes transversa* (Guenee)	Leaf	0.61	0.44	Minor	Minor
19	Nolidae	Shoot and fruit borer	*Earias vittella* (Fabricius)	Shoot, fruit	0.00	2.44	-	Major
20	Crambidae	Cotton leaf roller	*Syllepte derogata* (Fabricius)	Leaf	8.86	8.46	Minor	Minor
21	Arctiidae	Bihar *hairy* caterpillar	*Spilosoma obliqua* (Walker)	Leaf	0.89	0.17	Minor	Minor
C	**Coleoptera**							
22	Chrysomelidae	White-spotted leaf beetle	*Monolepta signata* (Olivier)	Leaf, flower	0.33	0.17	Minor	Minor
23	Chrysomelidae	*Leaf* eating *beetle*	*Podagrica* sp.	Leaf	19.13	7.95	Major	Minor
24	Curculionidae	Ash weevil	*Myllocerus discolor* (Boheman)	Leaf	0.72	0.30	Minor	Minor
25	Meloidae	Blister beetle	*Mylabris pustulata* (Thunberg)	Flower buds and Flower	15.50	0.00	Major	-
D	**Diptera**							
26	Agromyzidae	Serpentine leafminer	*Liriomyza trifolii* (Burgess)	Leaf	0.97	0.88	Minor	Minor
E	**Orthoptera**							
27	Pyrgomorphidae	Tobacco grasshopper	*Atractomorpha crenulata* (Fabricius)	Leaf	0.30	0.20	Minor	Minor
F	**Thysanoptera**							
28	Thripidae	Onion thrips	*Thrips tabaci* (Linderman)	Leaf	2.27	4.26	Minor	Minor

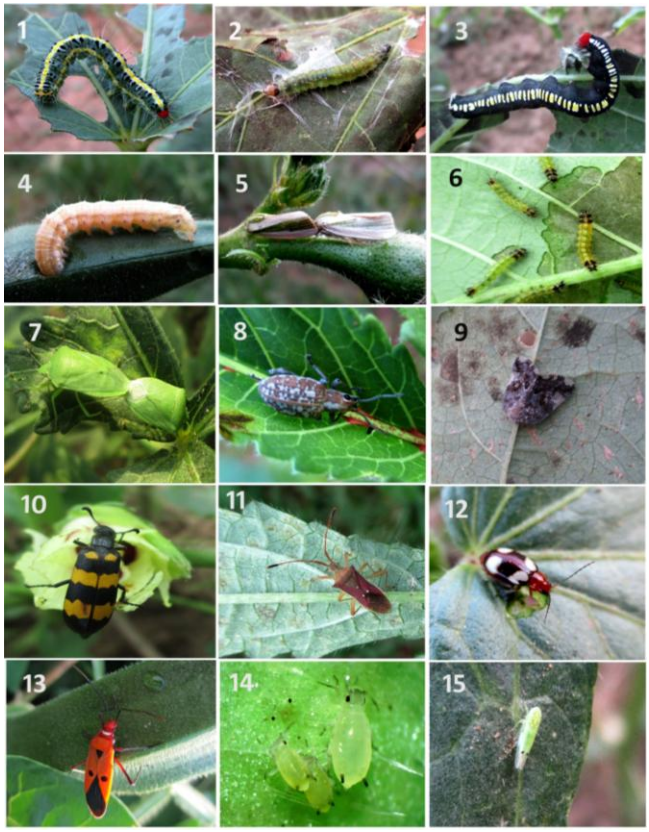

Fig 2: Insect pests of okra: 1. *Xanthodes transversa*, 2. *Syllepte derogata*, 3. *Anomis fulvida*, 4. *Helicoverpa armigera*, 5. *Earias vittella*, 6. *Spilosoma obliqua*, 7. *Nezara viridula*, 8. *Myllocerus discolor*, 9. *Ricania speculum*, 10. *Mylabris pustulata*, 11. *Cletus punctiger*, 12. *Monolepta signata*, 13. *Dysdercus cingulatus*, 14. *Aphis gossypii*, 15. *Amrasca biguttula biguttula*

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