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RESEARCH ARTICLE

Arthropod diversity and abundance in sugarcane germplasm at Kannur, India

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Abstract

The diversity and abundance of terrestrial arthropod fauna were assessed in sugarcane germplasm collection maintained in a crop-island scenario in the heartland of the Kannur district, Kerala State, India. A total of 523 invertebrates belonging to ten taxonomic orders viz., Orthoptera, Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, Blattodea, Mantodea and Araneae were recorded in the study. In terms of abundance, Hymenoptera recorded the highest constituting 21.41% of all individual morpho-species recorded, followed by the Coleoptera with 20.84% and Hemiptera with 19.50%. Arthropod richness across crop assemblages revealed that various crop assemblages tend to support specific arthropod groups in greater abundance. The mean arthropod taxa diversity per week differed significantly between different crop assemblages and there was a considerable level of decrease in number in the post man-made disturbance scenario. In both pre and post-man-made disturbance scenarios, the highest mean arthropod per week was recorded in the blocks of *Saccharum officinarum* followed by the blocks of foreign hybrids, *Saccharum* species complex and Indian hybrids block. The Shannon index value ranged from 1.86 to 2.12. The highest diversity (H'= 2.12) of communities was found in the block of foreign hybrid crop assemblage whereas lowest diversity (H'= 1.86) was recorded in the Saccharum species complex. The Simpsons index complemented the results of Shannon index. Importantly, the man-made disturbance had contributed negatively to the community diversity in the crop assemblages. In a pair-wise comparison measured through Jaccard's Index revealed that crop assemblages had expressed considerable differences in the community and diversity among them in both pre and post man-made disturbance scenarios.

Keywords: Sugarcane; Arthropods; Diversity; Abundance; Germplasm; Agroecosystem

Introduction

The ICAR- Sugarcane Breeding Institute Research Centre exists in the heartland of the Kannur district, Kerala State, India hosting 3377 global collections of sugarcane germplasm. The collections include *Saccharum officinarum, S.barberi, S.sinense, S.robustum, S. edule, S.spontaneum,* hybrids of Indian and foreign origin (*Saccharum* spp. hybrids) and allied genera such as *Erianthus, Narenga,* and *Sclerostachya* which naturally created a heterogeneous habitat differing from the ecosystem of commercially cultivated *Saccharum* spp. hybrids. The man-made ecosystem of sugarcane germplasm existing for more than five decades since the establishment of the centre in 1962 supported more diverse arthropods (Mukunthan and Nirmala 2002; Mahesh et al. 2019; Mahendran et al. 2020), in comparison to the surrounding urban environment. The diversity of some arthropods changes on a seasonal or annual time scale, due to several factors such as small size, short lifespan and high reproductive rates which make them more suitable indicators of environmental changes (Booth & Grime, 2003). While human activities are negatively impacting biodiversity via multiple mechanisms, land use change is widely considered to be the primary factor (Wilson 2002). Anthropogenic disturbances such as logging, clearing, and trampling also alter the arthropod diversity in ecosystems (White and Pickett 1985). The review by Miles et al. (2019) highlights the numerous factors that are altered in urban agroecosystems, which in turn affect plant resources and the arthropod community.

Considering the importance of the arthropods and the lack of a holistic study on arthropod diversity in sugarcane germplasm collections, a unique ecosystem assessment of the diversity and abundance of aboveground arthropods communities was made in detail.

Materials and Methods

Site description

The man-made agro-ecosystem mostly comprising sugarcane germplasm used in the study is located (11°52' N, 75°25' E, 11m MSL) in the Kannur District, Kerala state, India approximately 200 km from the commercial sugarcane belt, making it a sugarcane-island. The germplasm collection is planted afresh every year during the January-February adjacent to the crop of the previous year which is retained till the fresh crop gets established. Thus, the continuity of sugarcane crop is available for the arthropod community throughout the year. Further, the centre is islanded from the zone of commercial sugarcane fields and managed following recommended agricultural practices. The climate of the centre is of humid tropical monsoon climate with heavy seasonal precipitation. The period of June-September is the wettest in the year during south-west monsoon, with occasional localized flooding. The four sugarcane germplasm crop assemblages i.e Saccharum officinarum, Saccharum species complex (comprising *S.barberi, S.sinense, S.robustum* and *S. edule*), foreign hybrid and Indian hybrid within the site were considered for the present study.

Arthropod sampling

The above-ground arthropods or plant-dwelling arthropods that occur in the sugarcane agroecosystem were considered for the study. The study also incorporated the impact of man-made disturbance and the resultant drastic reduction in vegetation cover due to human activities such as treading, de-propping, bulk cutting, bundling, and removal of suitable canes for planting material. Thus, the month of January-March when canes are in the matured stage with fully developed canopy was considered an ideal time to incorporate the man-made disturbance and also sample a comprehensive arthropod community. The methods such as visual observation, direct handpick were used for arthropod observation and collection. The collected arthropod taxa were assessed following a rapid and cost-effective method involving classification to morpho-species level. It has been shown that this method can provide estimates of richness and turnover similar to methods that make use of species classified by taxonomists (Oliver and Beattie 1996). Care was taken to ensure that a morpho-species was regarded as the same 'species' for the entire sample (across four crop assemblages in the ecosystem) by compiling a photographic guide to which new individuals were compared. Classifications follow Picker et al. (2004) and Scholtz and Holm (1985). The number and abundance of each morpho-species was further determined for each crop assemblage. All specimens which were collected during the survey were identified up to order level.

The records of above-ground arthropods had been done in randomly selected sites of four crop assemblages within the existing ecosystem. From each crop assemblage, four corners and two centres were selected as sampling units, and a block of 12 rows (2m) in each sampling unit was considered for arthropod sampling. The sampling was done every day and each sampling session comprises of 1.5 hours in the forenoon (9:0 am to 10.30 am) and 1.5 hours in the afternoon (2:30 pm to 4 pm). The six weeks of continuous sampling until the initiation of man-made disturbance (considered pre man-made disturbance) and six weeks of continuous sampling after the completion of man-made disturbance (considered post man-made disturbance) were done and no sampling was done during the man-made disturbance period.

Biodiversity quantification

Two measures of biodiversity viz., The Shannon index (H' also termed the Shannon-Wiener index) and the Simpson index (D) (Shannon, 1948; Spellerberg et al. 2003) were used to quantify. The study also considered Jaccard's similarity index (Jaccard, 1912) which was used to compare diversity among the pre and post man-made disturbance in the ecosystem.

$$Shannon\ index = -\sum_{i=1}^{\infty} p_i \ln p_i$$

$$Simpson's\ index = \sum_{i=1}^{\infty} \frac{n_i(n_i-1)}{N(N-1)}$$

$$Jaccard's\ index = \frac{S_c}{S_a + S_b + S_c}$$

Where *pi* is the proportion of individuals found in morpho-species "i" and estimated as pi = n_i/N, where n_i is the number of individuals in species i and N is the total number of individuals in the community. S_a and S_b are the numbers of species unique to samples a and b, respectively, and S_c is the number of morpho-species common to the two samples.

Results and Discussion

Diversity and abundance of above-ground arthropods

The diversity and abundance of above-ground arthropods in different crop assemblage blocks were studied in detail. A total of 523 invertebrates of ten taxonomic orders, Orthoptera, Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, Blattodea, Mantodea and Araneae were recorded in the study. Hymenopterans were the most abundant constituting 21.41% of all individual morphospecies recorded, followed by the coleopterans with 20.84% and hemipterans with 19.50% (Fig.1). The least abundant orders

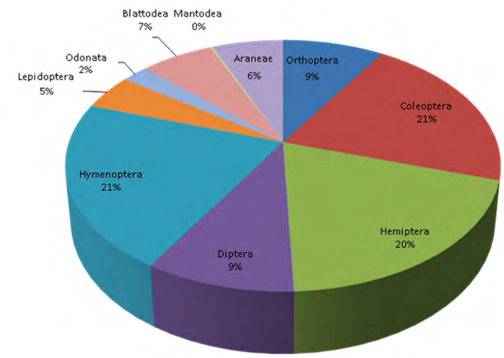

Figure 1. Percentage composition of arthropods collected in the study

were the Lepidoptera, Odonata, and Mantodea with 4.59%, 2.29% and 0.19%, respectively. Results of arthropod richness across crop assemblages revealed that each crop assemblage supported specific arthropod groups in greater abundance. Vijayababu et al. (2016) have studied the insect fauna in sugarcane field at Managaseri village, Virudhunagar District Tamil Nadu and identified seven orders of insects and found Orthoptera (33.33%) was the most dominant taxa followed by Hemiptera (20%), Hymenoptera (20%) and Coleoptera (13.33%).

The mean arthropod taxa diversity per week differed significantly across the crop assemblages and there was a considerable level of decrease in number in the post man-made disturbance scenario (Fig. 2 & 3). The highest mean arthropod per

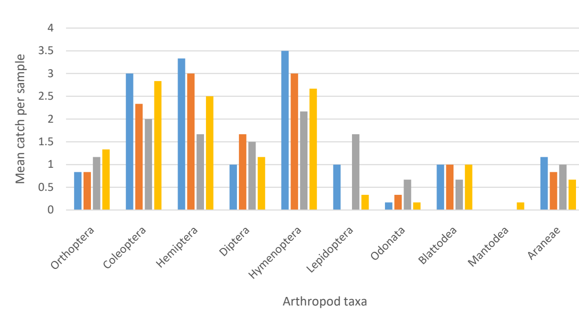

Figure 2. Mean arthropod catch per week under different crop assemblages (pre man-made disturbance)

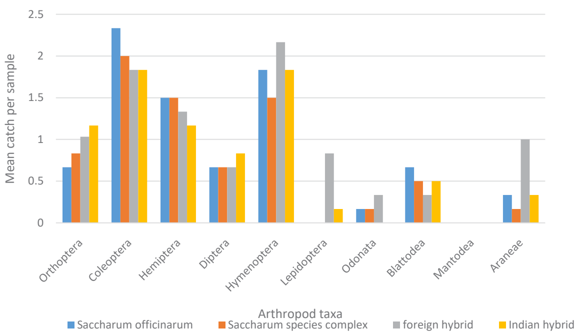

Figure 3. Mean arthropod catch per week under different crop assemblages (post man-made disturbance)

sample (15.00) was recorded in the *S. officinarum* crop assemblage followed by *Saccharum* species complex (12.99), Indian hybrid (12.83), and foreign hybrid (12.50) during pre man-made disturbance scenario. Similarly, the highest mean arthropod per sample (9.53) was recorded in the foreign hybrid crop assemblage followed by *S. officinarum* (8.16), Indian hybrid (7.83) and *Saccharum* species complexc (7.33) during post man-made disturbance scenario (Fig. 4).

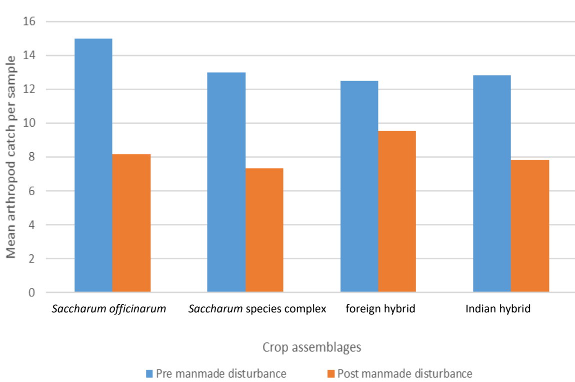

Figure 4. Mean total arthropod catch per sample under pre and post manmade disturbance in different crop assemblages

Biodiversity indices

The Shanon index typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. Similarly, the present study in the sugarcane agro-ecosystem yielded similar result with Shannon index value ranges from 1.86 to 2.12 (Table 1). The Shannon index is directly proportional to the richness and the evenness of the community. The highest diversity (H'= 2.12) of communities was found in the foreign hybrid crop assemblage block whereas lowest diversity (H'= 1.86) was recorded in the *Saccharum* species complex. Earlier studies have found that plant diversity increases arthropod diversity with particularly strong effects on abundance (Haddad et al. 2009; Ebeling et al. 2018). In the present study, each crop assemblage is a mixture of germplasm accessions in varied densities that created a habitat of high plant diversity, in turn, contributed to varied arthropod diversity. Interestingly, *Saccharum* species complex crop assemblage comprises more diverse plants with the presence of germplasm accessions belonging to four different species recorded lowest diversity might be due to the lesser host plant densities that also consistent with the resource concentration hypothesis (Root 1973; Stephens and Myers 2012) which proposes that arthropods are more abundant at higher host plant densities. The Simpson's index *(D)* complemented the findings of Shannon index with the measure of dominance or evenness being highest in the foreign hybrid followed by Indian hybrid crop assemblages. Importantly, man-made disturbances had contributed negatively to the community diversity and drastically reduced its richness in the crop assemblages (Table 1).

Jaccard's index was used to find the similarity level and comparison between communities of four crop assemblages viz., *S. officinarum, Saccharum* species complex, foreign hybrid and Indian hybrid with pre and post man-made disturbance in the ecosystem. The results are shown in Table 2. Jaccard Index value indicated an intuitive measure of similarity between the two crop assemblages and could summarize the fraction of species they share. As a pair-wise measure, variation in Jaccard's index in accordance to the environmental differences between the blocks were examined. In pre man-made disturbance scenario, crop

Table 1: Biodiversity indices for different crop assemblages in sugarcane agro-ecosystem

Crop assemblage block	Pre man-made disturbance			Post man-made disturbance		
	Shannon index *(H')*	Simpson index *(D)*	Simpson diversity *(1-D)*	Shannon index *(H')*	Simpson index *(D)*	Simpson diversity *(1-D)*
Saccharum officinarum	1.94	0.10	0.89	1.54	0.08	0.92
Saccharum species complex	1.86	0.10	0.89	1.79	0.08	0.92
Foreign hybrid	2.12	0.05	0.94	2.01	0.07	0.93
Indian hybrid	1.99	0.08	0.91	1.87	0.06	0.94

Table 2: Jaccard's index value for the crop assemblages prior to man-made disturbance

S.No.	Blocks compared		S_a	S_b	S_c	Jaccard's index
1.	*Saccharum officinarum*	*Saccharum* species complex	1	0	8	0.89
2.	*Saccharum officinarum*	Foreign hybrid	0	0	9	1.00
3.	*Saccharum officinarum*	Indian hybrid	1	0	9	0.90
4.	*Saccharum* species complex	Foreign hybrid	1	0	8	0.89
5.	*Saccharum* species complex	Indian hybrid	2	0	8	0.80
6.	Foreign hybrid	Indian hybrid	1	0	8	0.89

assemblages had shown considerable differences among them, though *S.officinarum* and foreign hybrid block did not differ significantly (Table 3) whereas the blocks of *S. officinarum* and Indian hybrid block had expressed considerable difference in the community and diversity among them. Moreover, pairwise comparison of *Saccharum* species complex- foreign hybrid and foreign hybrid- Indian hybrid elucidated similar community diversity in the pre man-made disturbance scenario. Importantly, among all pairs compared, the pair of *Saccharum* species complex and Indian hybrid block indicated more diverse community. In case of post man-made disturbance condition, interestingly three pairs viz., *Saccharum officinarum-Saccharum* species complex, *Saccharum officinarum*-Indian hybrid and *Saccharum* species complex-Indian hybrid have shown no difference of diversity among them with maximum Jaccard index value (=1.00). It is to be noted that Jaccard's index only utilizes the richness component of diversity since it does not entail any information on abundance (Magurran, 2004).

Table 3: Jaccard's index value for the crop assemblages post man-made disturbance

S.No.	Blocks compared		S_a	S_b	S_c	Jaccard's index
1.	*Saccharum officinarum*	*Saccharum* species complex	0	0	8	1.00
2.	*Saccharum officinarum*	Foreign hybrid	1	0	9	0.90
3.	*Saccharum officinarum*	Indian hybrid	0	0	8	1.00
4.	*Saccharum* species complex	Foreign hybrid	1	1	8	0.80
5.	*Saccharum* species complex	Indian hybrid	0	0	8	1.00
6.	Foreign hybrid	Indian hybrid	1	0	8	0.89

The man-made disturbances considerably influenced the diversity of communities in the different crop assemblages and perhaps reduced the existing diversity of communities. The present study ecosystem is a sugarcane island in a dynamic urban setting that provides shelter to the largest arthropod community highly influenced by agricultural practices being implemented. The implementation of conservative and bio-intensive management practices helps in preserving these precious arthropod communities.

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