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Comparative abundance of insects' diversity in cotton crop at two dissimilar growing seasons of selected village in Thoothukudi, Tamil Nadu, India.

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ABSTRACT: Cotton (*Gossypium hirsutum* L.) one of the utmost agriculturally important fiber crops and play a significant role in economics of India, they are healthy grown in the tropical and sub-tropical regions of the world wide. More than 1000 insect fauna accompanied with cotton is rich and diverse including insect pests, pollinators and natural enemies. Insects possess a positive impact on ecosystems through prey-predator contact, soil enhancement, and bio-indicative behaviours therefore, maintaining biodiversity on agricultural land is vital from both a conservational and marketable point of view this study designed with objectives, to recorded and identified insect fauna in cotton field at two different environment periods in selected village (8°36‘09.4"N 77°54‘09.0"E) at Thothukudi district. In irrigated seasons totally 25 insect's species were spotted gone to the 7 orders and 22 families and rainfed 18 insect's species were noticeable belonging to the 7 orders and 16 families. The maximum number 36 % and 33. 33% were observed on Hemiptera order insects at both irrigated and rainfed seasons respectively. Orthoptera Hemiptera, Lepidoptera and Mantodea order insects dominantly available in irrigated seasons whereas Hymenoptera, Coleoptera and Neuroptera order insects dominantly observed in rainfed season. Irrigate season has documented 18 family's' insect's species and significantly ($p = 0.003$) more number (12%) of Coccinellidae family insects are recorded. Rainfed seasons 16 family's insect's species were noted but Coccinellidae and Hymenopodidae (11.11%) family's insects dominantly available. Totally, 25 insect species have been noted, but nearly 48% and 28% insect species belong to the cotton pest at irrigated and rainfed seasons condition respectively. Cotton plant mostly affected Hemipteran insect order in both seasons at 36 and 33.33% at irrigated and rainfed seasons respectively. The didn't affect any pollinator species but different seasons alter the distribution of natural enemies. Irrigated and rainfed condition, eleven and seven natural enemies were recorded and significantly a greater number of *C. congregata* ($p = 0.003$) and *C. transversalis* ($p = 0.005$) are respectively observed. Findings help to understand a diverse group of insects' biodiversity existing in two dissimilar seasons of cotton crop field.

Keywords - Distribution, diversity, insect, cotton, pest, pollinators, predators.

Introduction

Cotton [*Gossypium hirsutum* L. (Malvaceae: Malvales)] is one of the most commercially and agriculturally important fibres crop (King of fibres) in word wide principally in India, performance a key role in financial, political and social affairs of the world (Mallesh and Sravanthy, 2021) [1]. Usually called as "White gold", well grown in the tropical and sub-tropical regions of the world wide (Shah *et al*., 2017) [2], mostly necessity sun light at 180- days with temperature 28 to 35˚C (Afzal 1986) [3]. The crop requires approximately 30 inches of rain or irrigation (Shah *et al*., 2017) [2]. The country is bestowed with diverse climatic conditions from the north to the south, suitable to grow all four cultivated cotton species specifically at *Gossypium herbaceum*, *Gossypium arboreum*, *Gossypium barbadense*, and *Gossypium hirsutum*. The species *G. herbaceum* and *G. arboreum* are native to the old world, also called Asiatic cotton, whereas *G. hirsutum* and *G. barbadense* are the new world cotton species, called upland and Egyptian cotton, respectively. For the reason that of its evolutionary history, *G. arboreum* is generally recognized as Desi cotton in India (ICAC 2019-2020) [4]. Cotton varieties under each species with specific fiber property traits and agronomy could be grown in northern states of Punjab, Haryana and Rajasthan; central zone states of Maharashtra, Gujarat, Madhya Pradesh and Odisha; and south zone states of Andhra Pradesh, Telengana, Karnataka and Tamil Nadu (Santhanam and Sundaram, 1999; Rajendran *et al*., 2018) [5, 6]. Cotton provides a means of support to 6 – 6.5 million farmers and around 60 million people engaged in cotton-related activities in India (Nyakatawa *et al*., 2001; DCD 2017: Raza *et al*., 2019; Tenguri *et al*., 2024) [7 - 10]. India resides in largest cotton acreage (13.373 m ha) and manufacture (36.5 m bales, 1 bale=170 kg) in the world. Geographical zones have distinct bio geographical features with varying climate and soil. Though, India shares largest area under cotton, however Indian

cotton productivity is lowest (464 kg lint/ ha) due to variety of reasons, among them damage due to various arthropod pests, be situated one of the major yields limiting factors (Nagrare *et al*., 2022) [11]. It is useful in producing five basic products i.e. lint, oil, seed meal, hulls and linters. The plant formed large white and yellowish white in colour flowers, it will fascinate insects. The insect fauna associated with cotton is rich and diverse together with bees, flies, butterflies and beetles, ladybird beetles, ants, ground beetles, syrphids, praying mantis, tinichid flies, spiders and predators etc.., (Vijaya Priya *et al*., 2019) [12]. However, more than one thousand insect species originate on cotton, Insects are the most effective and diversified collection of multicellular organisms on earth. Insects can have a confident impact on ecosystems through prey-predator dealings, soil upgrading, and bio-indicative behaviors (Bindu Bennet *et al*., 2022) [13]; therefore, maintaining biodiversity on agrarian land is vital from both a conservational and profitable point of view. In an ecosystem, this biodiversity provides a range of ecological services that complement one another and combine to create a stable, sustainable ecosystem. (Nee 2004) [14]. They play an indispensable role in key ecological processes as pollination, pest control, decomposition, and the preservation of wildlife species (Pires *et al*., 2014; Cusser *et al*., 2016 [15, 16]. Among these insect pests of cotton, which causes harvest losses up to 30-50% (Ashfaq *et al*., 2011; Kabissa, 2015; Asif *et al*., 2016) [17-19]. Only a few works are available in comparative studies of insect fauna in two dissimilar seasons at the same cotton field location. Hence this study was designed with objectives, to record and identify insect fauna in cotton fields at two dissimilar environment periods. The outcome helps to provide more information on cotton insect species composition in selected villages at two dissimilar environmental conditions as well as Tamil Nadu and India.

MATERIALS AND METHODS

Data collection

Based on the resident accessibility cotton field (Variety SVPRC 5) at two dissimilar seasons (Irrigated and rainfed seasons) and effortlessly data collection purpose, this study was conducted at cotton farmers' fields of Malavarayanatham (8°36‘09.4"N 77°54‘09.0"E) (Figure 1), Tuticorin district, Tamil Nadu, India. Data were detected during the season at both irrigated (March 2019 – May 2019) and rainfed (December 2020 – February 2021) seasons. The Studded cotton field zone was separated into 90 plots, each measuring 8 by 8 meters and containing 10 rows and ten plants (100 plants). Randomly taking 10 plots, each plot nominated 10 plants to record composition of insect species, quantity and categories of insects, biology giving to the method of Bohmfalk *et al*. (2018) [20]. The data were taken afterwards emergence of cotton seedlings at 60 days, 90 days and 120 days. Each plot is marked with labelled name boards to help record data at particular time intervals and two differential stages like summer and winter seasons (Lusana *et al*, 2019) [21].

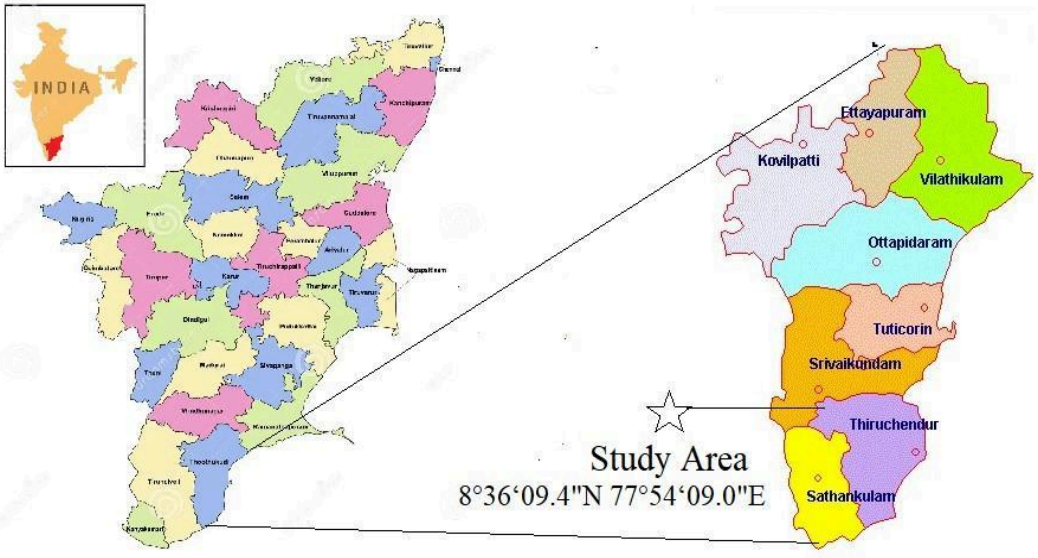

Figure 1: Map showed the study are of selected villages (8°36‘09.4"N 77°54‘09.0"E) Tuticorin district, Tamil Nadu, India

Diversity index

To measure diversity (biodiversity) insects at selected cotton fields and their diversity index calculated using the Shannon-Weiner index (H') (Shannon and Wiener, 1949) [22] method, the equation is as follows.

Shannon-Weiner index (H')

H' = − Σsi= 1 pi In pi

Where H' = Shannon-Weiner index, Pi = ni/N

ni = Number of individuals of a species, N =Total individuals of all species, ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

H' ≤ 1 = Low diversity, 1 < H' ≤ 3 = Moderate diversity, H' ≥ 3 = high diversity

Date analysis

All data is exposed with Analysis Of Variance (ANOVA) (SPSS V 16) (Finney, 1971) [23] then subjected to Tukey’s tests and significance was expressed at 0.05% level.

RESULTS AND DISCUSSION

Irrigated seasons

Insect species, order, family wise distribution

In irrigated seasons wholly 25 insects species were spotted belonged to 7 orders and 22 families (Table 1) which including *Amrasca devastans* (Distant) (*A. devastans*), *Aphis gossypii* (Glover) (*A. gossypii*), *Apis florea* (Fabricius), *Atractomorpha crenulata* (*A. crenulate*) (Fabricius), *Bemisia tabaci* (Gennadius) (*B. tabaci*), *Coccinella transversalis* (Fabricius) (*C. transversalis*), *Cheilomenes sexmaculata* (Fabricius) (*C. sexmaculata*), *Cotesia congregata* (Say) (*C. congregata*), *Dysdercus koenigii* (Fab) (*D. koenigii*), *Danaus gnutia* (Cramer) (*D. gnutia*), *Diabolocatantops pinguis* (Stal) (*D. pinguis*), *Earias vittella* (Fabricius) (*E. vitella*), *Euantissa pulchra* (Fabricius) (*E. pulchra*), *Mallada boninensis* (Navas) (*M. boninensis*), *Micraspis discolor* (Fabricius) (*M. discolor*), *Nezara viridula* (Linnaeus) (*N. viridula*), *Odontomantis planiceps* (Haan) (*O. planiceps*), *Oxycarenus hyalinipennis* (Costa) (*O. hyalinipennis*), *Phenacoccus solenopsis* (Tinsley) (*P. solenopsis*), *Paederus fuscipes* (Curtis) (*P. fuscipes*), *Rhynocoris fuscipes* (Fabricius) (*R. fuscipes*), *Ropalidia marginata* (Lepeletier) (*R. marginata*), *Spodoptera litura* (Fabricius) (*S. litura*), *Sphodromantis gastric* (Stal) (*S. gastric*) and *Spilostethus hospes* (Fabricius) (*S. hospes*) (Table 1).

Table 1: Distribution of insect species along with family and order name in two different environmental conditions.

	Irrigated Seasons			Rainfed seasons		
S. No	**Insect species**	**Family**	**Order**	**Insect species**	**Family**	**Order**
1.	*A. crenulate*	Pyrgomorphidae	Orthoptera	*A. crenulata*	Aphididae	Hemiptera
2.	*A. devastans*	Cicadellidae	Hemiptera.	*A. devastans*	Cicadellidae	Hemiptera.
3.	*A. gossypii*	Aphididae	Hemiptera	*A. florea*	Apidae	Hymenoptera
4.	*A. florea*	Apidae	Hymenoptera	*C. congregata*	Braconidae	Hymenoptera
5.	*B. tabaci*	Aleyrodidae	Hemiptera	*C. transversalis*	Coccinellidae	Coleoptera
6.	*C. transversalis*	Coccinellidae	Coleoptera	*D. genutia*	Nymphalidae	Lepidoptera
7.	*C. congregate*	Braconidae	Hymenoptera	*D. koenigii*	Pyrrhocoridae	Hemiptera,
8.	*C. sexmaculata*	Coccinellidae	Coleoptera	*D. pinguis*	Acrididae	Orthoptera
9.	*D. genutia*	Nymphalidae	Lepidoptera	*E. pulchra*	Hymenopodidae	Mantodea
10.	*D. koenigii*	Pyrrhocoridae	Hemiptera	*M. discolor*	Coccinellidae	Coleoptera
11.	*D. pinguis*	Acrididae	Orthoptera	*M. boninensis*	Chrysopidae	Neuroptera
12.	*E. vitelli*	Nolidae	Lepidoptera	*N. viridula*	Pentatomidae	Hemiptera
13.	*E. pulchra*	Hymenopodidae	Mantodea	*O. hyalinipennis*	Oxycarenidae	Hemiptera
14.	*M. discolor*	Coccinellidae	Coleoptera	*O. planiceps*	Hymenopodidae	Mantodea
15.	*M. boninensis*	Chrysopidae	Neuroptera	*P. fusipes*	Staphylinidae	Coleoptera
16.	*N. viridula*	Pentatomidae	Hemiptera	*P. solenopsis*	Pseudococcidae	Hemiptera
17.	*O. hyalinipennis*	Oxycarenidae	Hemiptera	*R. marginata*	Vespidae	Hymenoptera
18.	*O. planiceps*	Hymenopodidae	Mantodea	*S. gastric*	Mantidae	Mantodea
19.	*P. fuscipes*	Staphylinidae	Coleoptera	-	-	-
20.	*P. solenopsis*	Pseudococcidae	Hemiptera	-	-	-
21.	*R. marginata*	Vespidae	Hymenoptera	-	-	-
22.	*R. fuscipes*	Reduviidae	Hemiptera	-	-	-
23.	*S. gastric*	Mantidae	Mantodea	-	-	-
24.	*S. hospes*	Lygaeidae	Hemiptera	-	-	-
25.	*S. litura*	Noctuidae	Lepidoptera	-	-	-

Rainfed seasons

Insect species, order, family wise distribution

In rainfed seasons, wholly 18 insect's species were noticeable belonged to the 7 orders and 16 families (Table 1) which including *A. devastans, A. crenulata, A. florea, C. congregata, C. transversalis, D. genutia, D. koenigii, D. pinguis, E. pulchra, M. boninensis, M. discolor, N. viridula, O. hyalinipennis, O. planiceps, P. fusipes, P. solenopsis, R. marginata* and *S. gastric* nevertheless quantity of insect and family is dissimilar. In this finding displayed environmental circumstances crucially play insects fauna diversity in that studied cotton crop. Both seasons, planting identical of cotton varieties seeds at identical locations but reduced insects' population at cotton fields for the reasons of environment conditions. The rainfall seasons principally decreased the quantity of insect's species diversity in selected cotton fields. Finding of Lusana *et al*. (2019) [21] too conformed rainfall seasonal reduced the insect's population. In both irrigated and rainfed, those conditions have been noted at similar order of insects like Orthoptera, Hemiptera, Hymenoptera, Coleoptera, Lepidoptera, Mantodea and Neuroptera but quantity is different. Maximum number 36 % and 33. 33% were observed on Hemiptera order insects at both irrigated and rainfed seasons respectively. Orthoptera Hemiptera, Lepidoptera and Mantodea order insects dominantly obtainable in irrigated seasons whereas Hymenoptera, Coleoptera and Neuroptera order insects dominantly obtainable in rainfed season (Figure 2). Hemiptera order insects are not only divers in the cotton field, which also highly divers in other crop fields when compared to the other order insect ordered (Siregar *et al*., 2017) [24].

In insect family levels, when compare to the irrigate season have documented 18 family's insect's species like Pyrgomorphidae, Cicadellidae, Aphididae, Apidae, Aleyrodidae, Coccinellidae, Braconidae, Nymphalidae, Pyrrhocoridae, Acrididae, Nolidae, Hymenopodidae, Chrysopidae, Pentatomidae, Oxycarenidae, Staphylinidae, Pseudococcidae, Vespidae, Reduviidae, Mantidae, Lygaeidae and Noctuidae but number different. In irrigated seasons significantly ($p = 0.003$) more number (12%) of Coccinellidae family insects are recorded (Figure 3). Similarly, Siregar *et al*. (2017) [24] reported that the family of Coccinellidae, highly diverse in the paddy field.

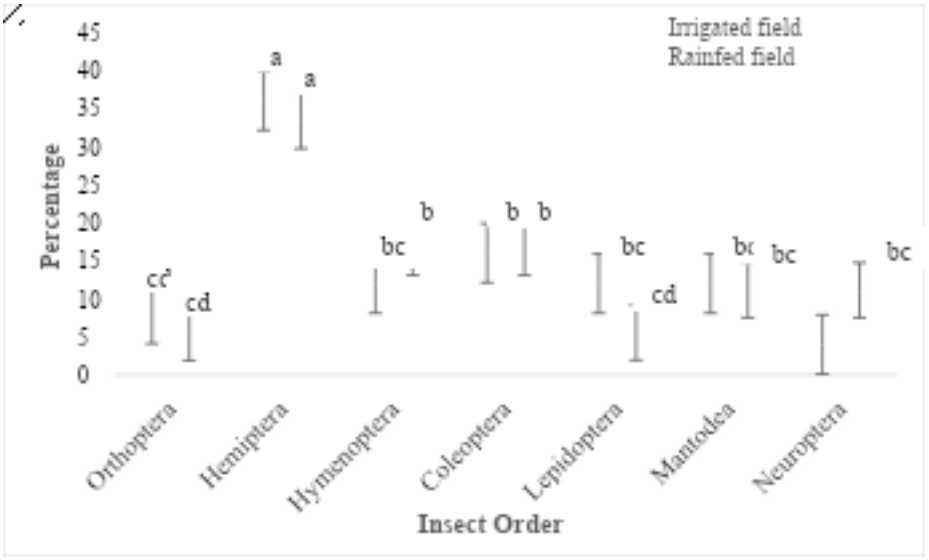

Figure 2: Distribution cotton insects at order level in different seasons (Irrigated and Rainfed) at selected field.

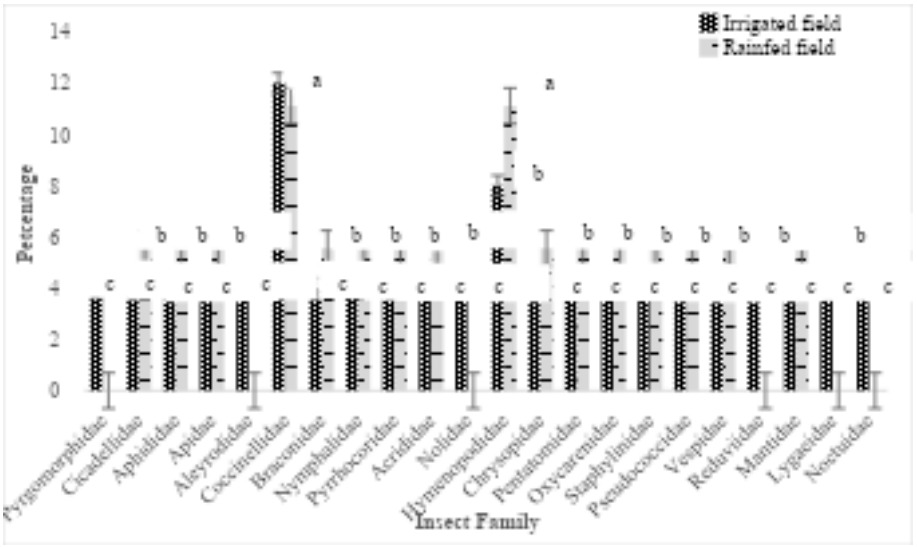

Figure 3: Distribution cotton insects at family's level in different seasons (Irrigated and Rainfed) at selected fields.

Rainfed seasons only present Cicadellidae, Aphididae, Apidae, Coccinellidae, Braconidae, Nymphalidae, Pyrrhocoridae, Acrididae, Hymenopodidae, Chrysopidae, Pentatomidae, Oxycarenidae, Staphylinidae, Pseudococcidae, Vespidae and Mantidae but ultimately 100% insignificantly (p = 1.003) reduced the Pyrgomorphidae, Coccinellidae, Nolidae, Reduviidae, Lygaeidae and Noctuidae family's insect's species. Coccinellidae and Hymenopodidae (11.11%) family's insects dominantly available in rainfed seasons (Figure 3). Rain, greatest natural factors that will interrupt the population of Pyrgomorphidae, Coccinellidae, Nolidae, Reduviidae, Lygaeidae and Noctuidae family insect species. When compare to the two seasons, irrigated season have rich divers in insects order, family and species, because of irrigated season have warm climate a condition which enhanced the growth phase of the crop plants as a result more amount of food available for insects and optimum temperature enhanced their proliferation of insects (Barrion and Litsinger, 1994; Menalled *et al*., 1999) [25, 26].

Pest diversity

The noted insect species were further classified into three groups via pest, pollinators and natural enemies. Cotton insect pest have different feeding mechanisms depending up on the mouth parts and feed (Birner *et al*., 2009) [27], first chewing type insect pests feed on the poles e.g. *E. insulana*, *Pectinphora gossypiella* (*P. gossypiella*), and *S. litura*, and second one sucking type insect's pest that feed liquid or juice of plants parts and honey of flowers e.g. *A. vastans*, *Thrips tabacii (T. tabacii)*, *Bemisia tabacii (B. tabacii)*, and *A. gossypii*. Totally, 25 insect species have been noted, but almost 48% and 28% insect species belong to cotton pests at irrigated and rainfed seasons conditions respectively (Table 2). Irrigate seasons the pest of *P. solenopsis* significantly (p = 0.001) is highly abundance and low number of pest species *D. pinguis* (p = 1.000) were noted per plant but invariable Shannon-Weiner index (H') result showed all the pest species have low diversity in nature. Similarly, rainfed conditions also noted the same result but the quantity of insects is different. When compared to the irrigated and rainfed condition, irrigated seasons observed a greater quantity of pest species (Table 2). This finding showed climatic conditions play a key role in distribution on insect pest species, previously Thorp and Cothran, (1984) [28]; Ahmed Abd *et al*. (2022) [29] conveyed increasing temperature, rainfall and humidity modify the availability of insect pest species.

Table 2: Distribution insect's pest in selected cotton field at different seasons (Irrigated and Rainfed).

	Irrigated				Rain fed			
S. No	**Pest**	**Average**	**P valve**	**Shannon-Weiner index (H')**	**Pest**	**Average**	**P valve**	**Shannon-Weiner index (H')**
1	*A. devastans*	7.0 ± 0.8^{c}	0.005	0.28	*A. devastans*	7.3 ± 1.2^{b}	0.003	0.292
2	*P. solenopsis*	16.2 ± 2.0^{a}	0.001	0.64	*P. solenopsis*	8.2 ± 1.5^{a}	0.002	0.328
3	*E. vitelli*	0.05 ± 0.04^{a}	1.037	0.002	*A. crenulata*	0.3 ± 0.1^{e}	0.242	0.012
4	*O. hyalinipennis*	14.0 ± 0.4^{b}	0.003	0.56	*O. hyalinipennis*	6.9 ± 1.9^{c}	0.006	0.276
5	*D. koenigii*	0.6 ± 0.2^{e}	0.060	0.024	*D. koenigii*	1.5 ± 0.5^{d}	0.139	0.06
6	*A. gossypii*	7.0 ± 0.8^{c}	0.005	0.28	-	-	-	-
7	*B. tabaci*	2.4 ± 0.7^{d}	0.007	0.096	-	-	-	-
8	*S. hospes*	0.02 ± 0.02^{h}	2.964	0.008	-	-	-	-
9	*A. crenulata*	0.1 ± 0.03^{f}	0.624	0.004	-	-	-	-
10	*N. viridula*	0.1 ± 0.05^{f}	0.863	0.004	*N. viridula*	0.1 ± 0.1^{f}	0.367	0.004
11	*S. litura*	0.1 ± 0.1^{f}	0.789	0.004	-	-	-	-
12	*D. pinguis*	0.04 ± 0.02^{g}	1.00	0.0016	*D. pinguis*	0.1 ± 0.1^{f}	0.435	0.004

- Not observed any pests
Same (^{abcd}) lowercase letter in column shows significance at 0.05% among the ECs.
$H' \leq 1$ = Low diversity, $1 < H' \leq 3$ = Moderate diversity, $H' \geq 3$ = high diversity

Cotton plants affected countless types of insect's pest including lepidoptera larva and sucking pests' identical leafhoppers, whitefly, thrips and aphids (Bale *et al*., 2008) [30]. In both seasons the Hemipteran insect order is dominantly available in 36 and 33.33% at irrigated and rainfed seasons respectively (Figure 2). Both seasons, pest populations are similar for the reasons of availability of feed. Hemipteran insect pests feed on cotton leaves juice and economically important crops are major food for sucking insect pests (Alfred Daniel *et al*., 2018) [31]. Sucking pests feed honeydew compositions in flowers, it will increasing the amino acids level as a finally result increased their own growth and fecundity of insect pest (Styrsky and Eubanks, 2006; Slosser *et al*., 2004) [32, 33]. Economically important crops give optimum condition to sucking (Hemipteran) pests and leads to the faster reproduction when compared to the other insect pest species (Amin *et al*., 2008) [34]. Optimum seasons, help to some of the Hemipteran cotton sucking pest female insects able to reproduce both with and without mating (Slosser *et al*., 2004; Fernandes *et al*., 2013) [33, 35,]. The above mentioned reasons, hence proved Hemipteran pest is highly distributed in selected cotton fields. Hemipteran sucking pest affected the morphological, anatomical appearance of cotton plant-like shape, colour which led to reduced plant growth and nutrient uptakes finally affected the cotton yield (Azmir *et al*., 2013) [36]. Cotton yield is decreased by several factors like heavy rain, high temperature as well as insects. Most importantly the insect pest is extremely answerable for dropping quality and quantity of cotton (Kaplan and Eubanks 2002) [37].

Pollinators diversity

In both irrigated and rainfed seasons two pollinators' species *A. florea* (p = 0.007, H= 0.02) and *D. genutia* (p = 0.056, H = 0.004) were recorded at same individual numbers also in per plants (Figure 4). In irrigated condition, eleven natural enemies *O. planiceps*, *R. fuscipes*, *C. sexmaculata*, *C. transversalis*, *M. discolor*, *S. gastric*, *E. pulchra*, *P. fuscipes*, *R. marginata*, *M. boninensis* and *C. congregata* were observed (Figure 4). Significantly (p = 0.003, H = 0.236) a greater number of *C. congregata* (5.9 insect per plant) at irrigated seasons. In rainfed condition seven natural enemies *O. planiceps*, *C. transversalis*, *S. gastric*, *E. pulchra*, *P. fuscipes*, *M. boninensis* and *C. congregata* were recorded and significantly (p = 0.005, H = 0.256) a greater number of *C. transversalis* also observed. When compared to the irrigated and rainfed condition, natural enemies *R. fuscipes*, *C. sexmaculata*, *M. discolor*, *R. marginata* are 100% reduced. The selected cotton field irrigated and rainfed condition favored *C. congregata* and *C. transversalis* natural enemies' population respectively (Figure 4).

Natural enemies' diversity

Natural enemies including paradors are feed on cotton insect pest mostly prefer for soft body insects and sucking pest (Nielsen *et al*., 2009; Singh *et al*., 2016) [38, 39] as well as egg, larval, pupal and adult stages, that offer natural balance of insect biodiversity (Mallesh and Sravanthy, 2021) [1]. Moreover, predator's insect feed numerous insect's, reduced pest intake of feeding, as a result reduced oviposition capacity and enhanced the soil quality and nutrients (Choate and Drummond, 2011; Nagrare *et al*., 2022) [40, 11]. The number of pollinators and natural enemies are different in both irrigated and rainfed seasons for the two reasons via climatic condition and based on the food (Saikia S and Singaha naorem) [41]. In earlier Feltwell, (1986) [42] similarly found that pollinators and predator insect numbers moderately reduced due to unviability or low amount of feed (pest species) in cotton fields.

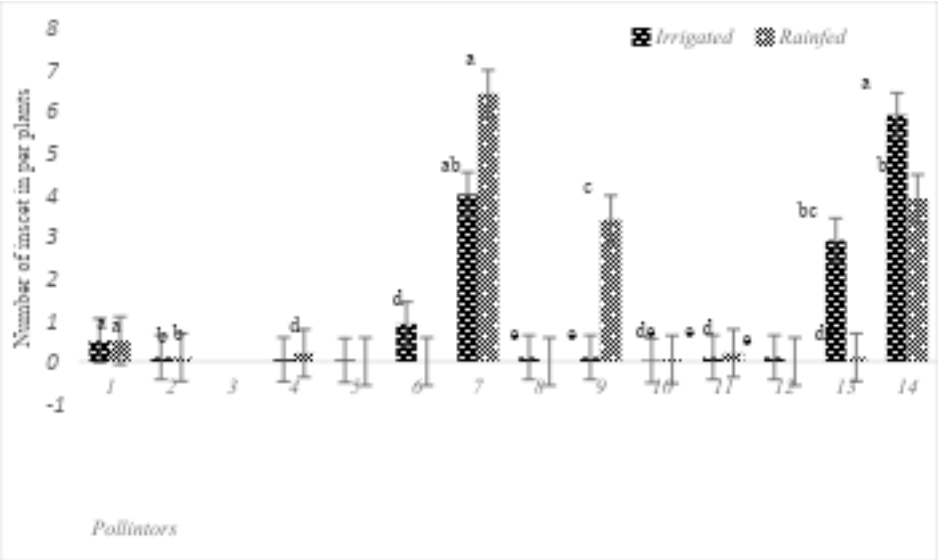

Figure 4: Distribution pollinators natural enemies at selected cotton fields in different seasons (Irrigated and Rainfed).

CONCLUSION

The selected cotton crop field villages don't have more knowledge about cotton and their insect species, insect pests, predators and pollinators. The current finding helped identify insect, insect pest, pollinators and natural enemies to local peoples and understanding of diverse groups of insects' biodiversity existing in this selected area and climatic condition. Finding also assistance to know how insects are important to the ecosystem and maintain insect fauna in the ecosystem.

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