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Effect of insecticide spraying on butterfly fauna in Cuddalore District, Tamil Nadu, India's agricultural environments

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Abstract
From January to May of 2024, a field study was carried out in Cuddalore District, Tamil Nadu, to evaluate quantitatively the effects of insecticide treatment on native butterfly species in agricultural settings. Field margins in agricultural landscapes can serve as butterfly (Lepidoptera) habitats. However, insecticide inputs may have an impact on field margins due to their close proximity to agricultural locations. Fifteen permanent line transects, each measuring 500 meters, were chosen at random from the vegetable and commercial crop producing zones. Important pollinators are negatively impacted by insecticides, which change their feeding habits and other vital behaviors. About 25 species, including those in the families Hesperiidae (02), Lycaenidae (06), Nymphalidae (08), Papilionidae (04), and Pieridae (05), varied significantly in terms of their relative abundance in regions where insecticides were sprayed as opposed to control areas. The fauna of butterflies at regions sprayed with insecticides often decreased. The current study contributes to our understanding of the survivorship status of butterfly species in environments affected by intensive agriculture and insecticide use.

Keywords: Butterflies, Insecticides, Agriculture, Diversity, Abundance

Introduction

In terms of population, insects outnumber all other terrestrial creatures and are found worldwide. The changing environment is the main factor influencing butterflies in their agricultural habitats (Pullin AS *et al*., 1995 [20] & Van Swaay C *et al*., 1999) [27]. due to ground burning, intensive farming methods, monoculture farming, artificial fertilizers used in agroecosystems, herbicides, and insecticides (Kearns CA *et al*., 1998 [12] & Goulson D *et al*., 2013) [8]. Because of this, the quality of the ecosystem has significantly changed, and many native butterfly species are now seriously threatened because they cannot find food or host plants during their development. Intensified use of modern agricultural landscapes is frequently observed, as evidenced by factors such as larger fields, fewer varieties of crops, fewer semi-natural habitats available, and higher inputs of agrochemicals (fertilizers and pesticides) in fields (Stoate *et al*., 2001 [24]; Robinson and Sutherland, 2002) [22]. A decline in pollinators is correlated with a reduction in suitable host plants and excessive use of fertilizers, herbicides, and insecticides in agricultural settings (Hanley ME *et al*., 2015) [10]. Studies on the loss of butterflies in agricultural areas are scarce. There are numerous variables linked to its demise. First and foremost, the biology of agricultural ecosystems is directly and fatally affected by the indiscriminate use of insecticides (Rands MR *et al*., 1986 [21] & Feber RE, *et al*., 1997) [7]. Since butterflies are among the most significant elements of terrestrial ecosystems, this is true for them (Thomas JA *et al*., 2001) [25]. Because studying butterflies can help one better understand the dynamics and structure of the biological population in a particular location (Ehrlich PR, 1994) [6]. The Indian state of Tamil Nadu contains the Cuddalore District. The district's cultivation is dominated by both agriculture and horticulture. Two primary locations were used for the study: commercial crop sites and vegetable crop sites. Thus, the current study was conducted since there is an urgent need to comprehend the effects of pesticides and insecticides on non-target species like butterflies.

Materials and Methods

Study area

The study was conducted at Bhuvanagiri, Kullanchavadi, and Panrutti of Cuddalore District during different cropping seasons at agriculture ecosystems in January to May for the year of 2024. The sampling site was further classified into two major crops growing areas *viz*., Commercial crop producing zone and (CCPZ) (E.g. Banana, Sugarcane, cashew nut, Jack fruit, coconut, Mango, Lemon, Jasmine, Maize, Groundnut, Castor, Sesamum) and Vegetables producing zone (VPZ) (E.g. Tomato, Brinjal, Drumstick, Ladies finger, Green chili, Pumpkin, snake gourd, Bottle gourd, Broad beans, Cluster beans, Ridge gourd, Radish, Bitter gourd)

Methodology

According to (Kunte K, *et al*., 2012) [15] fifteen permanent line transects (LTs) with a length of five hundred meters were chosen randomly. Personal interviews and the completion of a pre-tested questionnaire were used to gather information on the various pesticides that were sprayed on these crops during their production. Using the Visual Count Method (VCM) to count every butterfly discovered in the transect, observations were taken using the Pollard Walk Method (PWM) as per (Saarinen K. A., 2002 [23], Kunte K, *et al*., 2012 [15] & Guptha MB., *et al* 2012) [9]. According to (Feber RE, *et al*., 1997 [7], Saarinen K. A., 2002 [23], Longley M., *et al*., 1997 [16] & Pekin BK., 2013) [19], butterfly activity was observed both before and after Insecticide spraying.

Measure of butterfly diversity

The mortality, density, and quantity of butterfly species were recorded by closely observing both the insecticide-sprayed and non-sprayed areas. According to (Saarinen K.

A., 2002 [23], Dufrene M. *et al*., 1997) [5] the butterfly fauna was compared between CCPZ, VPZ, and cropping areas without the use of insecticides. Each transect's assemblage diversity was assessed using univariate methods, and survey replicates were combined into a single site observation to provide an overall picture of the butterfly assemblage from all surveys conducted at a given location (Chao *et al*., 2014) [3]. Furthermore, the Shannon Diversity Index (H1), Simpson (1-D), Shannon equitability (J), and Dominance (D) were calculated using standard methods as outlined by (Magurran AE) to determine the butterfly species diversity index before and after insecticide spraying.

Results

Twenty-two different types of insecticides are used in various agricultural settings (Table 1). This list includes insecticides such as Burofezin, Carbofuran, Clothianidin, Cypermethrin, D.D. Mixture, Deltamethrin, Dichlorvos, Dimethoate, Endosulfan and Fipronil, Imidacloprid, Lambda-Cyhalothrin, Malathion, Bromadiolone, Clothianidin, Cypermethrin, Acetaminophenone, Azadirachtin, Methomyl, Methyl Parathion, Oncentra Tecontatining, Phorate. Insecticide application is highest in the CCPZ, followed by the VPZ, and it is highest in all agricultural environments.

Abundance of Butterflies

There are about twenty-five species that are members of the following families Papilionidae (four species), Nymphalidae (eight species), Lycaenidae (six species), Hesperiidae (Two species), and Pieridae (five species). The members of the Pieridae family, including Eurema hecabe, Suastus gremius, Hasora badra, and Hesperiidae, were absent from CCPZ. Nevertheless, following the insecticide spraying at VGA, Suastus gremius of the Hesperiidae family, Castalius rosimon of the Lycaenidae family, and Catopsilia spp. of the Pieridae family were gone (Table 2). Following the use of insecticides, the number of butterfly species at various crop-growing locations dropped (Fig. 1).

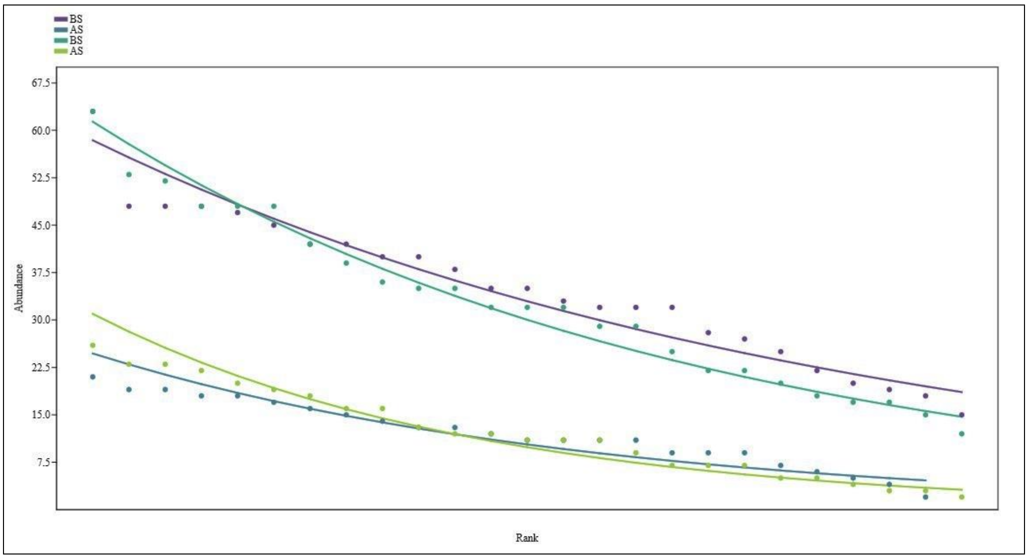

Fig 1: Abundance of butterflies at different crops before and after Insecticide application

Table 1: Insecticide used on various crops in Cuddalore District, agriculture ecosystems

S. No	Agricultural Ecosystem	Insecticides
1	Commercial crop producing zone and (CCPZ)	Burofezin, Carbofuran, Clothianidin, Cypermethrin, D.D. Mixture, Deltamethrin, Dichlorvos, Dimethoate, Endosulfan and Fipronil, Imidacloprid, Lambda-Cyhalothrin, Malathion, Bromadiolone, Clothianidin, Cypermethrin.
2	Vegetables producing zone (VPZ)	Acetaminophenone, Azadirachtin, Methomyl, Methyl Parathion, Oncentra Tecontatining, Deltamethrin, Dimethoate, Endosulfan, Melathione, and Phorate.

Table 2: Butterfly species abundance were measured in various crops in the Cuddalore District's agricultural ecosystems both before and after insecticide treatment.

Family	S. No	Scientific Name	Common Name	Butterfly abundance at different crop types			
				Commercial crop producing zone and (CCPZ)		Vegetables producing zone (VPZ)	
				BS	AS	BS	AS
				T	T	T	T
Papilionidae	1	*Papilio demoleus*	Lime butterfly	63	21	63	26
	2	*Pachliopta hector*	Crimson rose	48	19	53	23
	3	*Pachliopta aristolochiae*	Common rose	48	19	52	23
	4	*Papilio polytes*	Common moremon	48	18	48	22
Nymphalidae	5	*Danaus chrysippus*	Plain tiger	47	18	48	20
	6	*Ariadne merione merione*	Common castor	45	17	48	19
	7	*Junonia lemonias*	Lemon pansy	42	16	42	18
	8	*Euploea core*	Common crow	42	15	39	16

	9	*Acraea terpsicore*	Tawny coster	40	14	36	16
	10	*Danaus genutia*	Common tiger	40	13	35	13
	11	*Tellervo limniace*	Blue tiger	38	13	35	12
	12	*Melanitis leda*	Common evening brown	35	12	32	0
Pieridae	13	*Pieris rapae*	Cabbage white	35	11	32	11
	14	*Eurema hecabe*	Common grass yellow	33	0	32	11
	15	*Delias eucharis*	Common jezebel	32	11	29	11
	16	*Catopsilia spp*	Common emigrant	32	11	29	0
	17	*Cepora nerissa*	The common gull	32	9	25	7
Lycaenidae	18	*Lampides boetius*	Pea blue	28	9	22	7
	19	*Castalius rosimon*	Common Pierrot	27	9	22	0
	20	*Chilades parrhasius*	Small Cupid	25	7	20	5
	21	*Ereres lacturnus*	Indian cupid	22	6	18	5
	22	*Zizeeria karsandra*	Dark grass blue	20	5	17	4
	23	*Jamides celeno*	Common cerulean	19	4	17	3
Hesperiidae	24	*Hasora badra*	Common awl	18	0	15	3
	25	*Suastus gremius*	Indian palm bob	12	0	11	0

Table 3: Diversity Indices calculated between crop types before and after Insecticide application.

Sl. No	Study Site		Species Richness	Shannon Diversity Index (H)	Simpson Index (1-D)	Equitability (J)	Dominance (D)
1	CCPZ	BS	25	3.17	0.95	0.98	0.043
		AS	22	3.12	0.94	0.97	0.045
2	VPZ	BS	25	3.15	0.95	0.97	0.045
		AS	21	3.08	0.94	0.95	0.050

Diversity Indices of Butterfly Species

The Shannon diversity index was 3.17 at CCGA and 3.15 at VGA. It decreased to 3.12 and 3.08 at VPZ and CCPZ, respectively, after insecticides were sprayed. Additionally, prior to application, the Simpson and Equitability index was closer to 98 to 97. However, after the pesticides were sprayed, it dropped from 97 to 95 (Table 3). The Dominance index was 0.43, to 0.45 before insecticide application. However, it was raised to 0.45 at CCPZ and 0.50 at VPZ, respectively (Table 3).

Species richness

In CCPZ and VPZ, the species richness declined across the board. At VGA, there were only 21 species, while at CCGA, there were only 22 (Table 3). Prior to the application of insecticides, Table 3 shows that the Shannon diversity index was 3.17 and 3.15, supported by the 0.95 Simpson (1-D) index and equity at different crop kinds. However, with increased dominance (D) of 0.045 and 0.050 at both the CCPZ and the VPZ, the Shannon Index (H) dropped to 3.12 and 3.08, respectively (Table 3).

Discussion

Effects of applying insecticides on the species of butterflies

Due to insecticide spraying in the agricultural ecology, butterflies, which have extremely sensitive environments, reacted quickly to changes in their surroundings. The application of diverse Insecticides on different crops at CCPZ and VPZ at different plant stages has resulted in a significant reduction in the density and quantity of butterfly species. According to Vyas (1977) [28] and Chaudhary (1990) [4], pesticides are deposited on the leaves, pods, grains, and other plant body parts. According to (Agarwal SK., 2009) [1], the lingering toxicity of Insecticides hindered the growth and development of plant cells, tissues, and organ systems. Ultimately, it may cause morphological and metabolic changes, obstruct chlorophyll biosynthesis, and ultimately cause plants to perish. Thus, frequent insecticide applications will decrease the variety of flowers seen in the area (Moreby SJ. *et al*., 1999) [18]. Butterflies will undoubtedly relocate to other locations in quest of hosts and food plants when there is a shortage of flora. If not, they suffer from poisoning caused by pesticides. It's possible that all of these factors contributed to the lower butterfly species abundance in insecticide-sprayed areas. The observations of earlier scholars are supported by our observations. Furthermore, the density of the families Hesperiidae, Lycaenidae, Pieridae, and Nymphalidae decreased at CCPZ and VPZ. The butterflies in these families show a strong sensitivity to spray pesticides. This might have discouraged them from taking action and led to a decrease in abundance at these sites. Nevertheless, following the application of insecticides, Hasora badra, Suastus gremius, Eurema hecabe, Catopsilia spp., Hesperiidae family Pieridae family, and Nymphalidae family members Melanitis leda and Eurema badra were entirely missing from CCPZ and VPZ. According to (Goulson D. 2013) [8], some insecticides applied on plants could envenom butterflies that feed on nectar by penetrating tissues through their nectar. According to estimates made by (Lewis *et al*., 2011), a concentration of 3% methionine is enough to cause 100% death in several types of butterflies. Furthermore, it was shown by laboratory bioassay studies that introducing insecticides to a butterfly's diet would alter the diet's quality, which would then affect the physiological processes of the butterfly, including growth and development (Rands MR., *et al* 1986, [21] Feber RE., *et al* 1997 [7], Tiple AD., *et al* 2007) [26]. Therefore, it's possible that frequent, heavy pesticide applications on agricultural crops damaged the habitat and had an impact on butterfly species in agricultural environments (Brittain CA., *et al*., 2010) [2]. Consequently, the diversity and richness of butterflies in the area are positively impacted by the application of pesticides at various crop fields. Additionally, a decrease in the diversity of butterflies at different crop fields may lead to a fall in pollinators, which in turn may slow down the process of pollinating a number of plant species (Kleijn D., *et al*., 2000) [13]. Due to the lack of adequate host and food plants, this would change the survival rate of many butterfly species and result in the death of the egg, larva, and pupa. This could be one of the primary causes of the drop in a few butterfly species that has been reported at CCPZ and VPZ. To assess the poisoning effect of pesticides on native butterfly diversity in the agriculture environment, a small number of species belonging to the groups Hesperiidae, Pieridae, Nymphalidae, and Lycaenidae may be employed as indicator species. Given that agricultural landscapes are isolated areas of artificial ecosystems, they support a limited range of wild species of plants and animals (Hannon LE., *et al*., 2009). In an agricultural ecosystem, many crop kinds are planted in the landscape, and these crops are utilized for foraging, roosting, breeding, and resting by a variety of insect species, including butterfly species (Klein AM., *et al*., 2007) [14]. Scientific data generated during the current study could aid in conducting more in-depth research to develop strategies to conserve the native butterfly species within agriculture ecosystems. The studies would provide baseline scientific information on butterfly species survivorship at Insecticide-sprayed agriculture ecosystems.

Conclusion

Butterflies are emblematic species in many habitats; their existence within agricultural settings provides insight into the overall health of the ecosystem. In order to restore local biodiversity, it is therefore imperative that native butterfly species be considered. We demonstrated the effects of insecticides on butterfly populations in the Cuddalore District, given the significance of local disturbances. As seen by the butterflies' unhealthy clustering in reaction to local habitat changes, it may be assumed that insecticide may still be a threat to the quantity of butterflies in the research area. The study offers a chance to determine the total species richness of the butterfly fauna in the Cuddalore District study sites, at most. We anticipate that the work will serve as the foundation for a molecular strategy to learn more about the conservation and management of butterflies.

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