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Outbreak of *Catopsilia pyranthe* L. on Senna (*Cassia angustifolia* Vahl) and Migration in Western Arid Region of India

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ABSTRACT

Background: *Cassia angustifolia* Vahl, senna, known for medicinal properties belongs to family fabacea is a hardy plant, suitable for saline and rainfed conditions serving as a host for caterpillars of *Catopsilia pyranthe* L. butterflies suffering up to 90 per cent defoliation. An attempt was made to record butterfly migrations due to an outbreak of the lepidopteron pest on senna which is the first report on butterfly migration in western arid region.

Methods: Surveys made in different districts for accurate quantification of butterflies passing within 5 minute through a 10 meter wide strip. For diurnal pattern, observations were taken on hourly basis. Correlation of butterfly density with weather parameters was worked out.

Result: Migration was mainly in South West direction in a steady line connecting Jaisalmer, Jodhpur, Pali, Sirohi and Ajmer. The highest density (1360 butterflies/10m/5 minute) accounting for 16,320.0 butterflies/10m/hour and 97,920.0 butterflies/10m/day recorded in Keru (Jodhpur) representing bell shape curve of diurnal movement with a maximum activity between 12.00 noon and 1.00 PM.

Key word: Arid region, *Cassia angustifolia*, *Catopsilia pyranthe*, Migration, Outbreak.

INTRODUCTION

Cassia angustifolia Vahl, commonly known as senna, sonamukhi, belongs to family Fabacea and is a perennial shrub native of tropical Africa. Significance of this crop is due to its medicinal properties. In India, the plant was first introduced into Tirunelveli district from European countries during 18th century. It is a hardy plant species, suitable for saline and rainfed conditions and cultivated in parts of Gujarat, Rajasthan, Tamilnadu and Maharashtra (Jat *et al*. 2015). Kutch of Gujarat, Bikaner, Pali, Jodhpur and Jaisalmer are major senna cultivation areas in the country and cultivated more than 20000 ha (Kothari *et al*., 2005). Pest incidence is one of the problems of senna production (Jnanesha *et al*. 2018). Crop is attacked by numerous insect pests *viz*., *Aphis craccivora* Koch, *Catopsilia pyranthe* L, *Eurema hecabe* (L.), *Etiella zinckenella* Treit., *Melanagromyza obtusa* Malloch and *Lasioderma sericorne* Fb. (Baskaran *et al*., 2008; Marimuthu *et al*., 2018); Among these, *C. pyranthe* (Lepidoptera: Pieridae), mottled emigrant butterfly, reported regular and major defoliator of senna (Chaudhary and Sharavanan, 2009). Butterfly migrations have been well documented from Tamilnadu, Karnataka, Kerala, Gujarat, Maharashtra, Madhya Pradesh (Aitken, 1900; Evershed 1910; Palot *et al*., 2002; Kunte, 2005). However, none reported the origin of butterflies. Synchrony with host plant has been suggested as an important factor in the dynamics of many forest pests (Van Asch and Visser, 2007). Richard *et al.* (2017) found the positive association between precipitation and caterpillar abundance of *Platyprepia virginalis.* Present investigation attempts to link the outbreak of lepidopteron butterflies in senna resulting in a migration along western arid region with magnitude of swarm, source and climatic factors influencing migration.

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MATERIALS AND METHODS

Study area

ICAR-Central Arid Zone Research Institute, Regional Research Station Jaisalmer (Latitude 26°54'56.7"N, Longitude 70°54'30.04"E, Elevation 238.21 MSL) taken as investigation area is surrounded on the east by Jodhpur, on the south by Barmer and on the northeast by Bikaner possessing arid ecology. The major *kharif* crops of this region are cluster bean, pearlmillet, mung bean, groundnut and moth bean while chick pea, mustard and cumin are grown during *rabi* season. Besides this, senna belonging to Fabacea family is also predominantly gaining importance.

Observation on directional movement and density of migratory swarms

A vast migration of butterflies was observed in entire Jaisalmer during first week of September (07.09.2020). Surveys were also undertaken in nearby districts *viz*., Jodhpur, Pali, Ajmer and Sirohi, for further information on

the migration. Migration noticed upto Barmer, Bikaner, Jalore and Chittorgarh districts. Quantification was made in a 10 meter wide imaginary strip (Kunte, 2005) by recording the number of butterflies passing through this strip within 5 minute duration at different locations and confirming through a video shot across the 5m strip by playing in slow motion. As much as 11 such observations were undertaken between 8.0 AM to 6.0 PM on hourly basis for assessing diurnal pattern at research farm of CAZRI RRS Jaisalmer.

Field observation on infestation level and breeding behavior

Infestation level each of randomly selected 25 plants from five fields of senna crop were selected to record the insect stages and damage intensity.

Statistical analysis

Weather data on hourly basis collected from the Agro meteorology unit of CAZRI RRS Jaisalmer was correlated with butterfly population collected in a day through hourly counts (11 observations). Pearson correlation coefficient (r) was calculated using OP Stat software of Hisar Agricultural University, Hisar. Means and standard deviations of data sets were calculated, wherever required.

$$s = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$

s = sample SD; X - individual value; $\bar{X}$- sample mean; n = sample size.

RESULTS AND DISCUSSION

Directional movement and density of migratory swarms at different locations

Migration of *C. pyranthe* was started in early September (07.09.2020) and lasted up to end of September. Observations recorded on the migration of butterflies at different location's which revealed the variation in density of swarm movement. Highest density of swarm (1131 butterflies /10m /5 minute) was recorded in Lathi area on September 19th which equivalents to the 13,572.00 butterflies /10m/Hour and 81,432.0 butterflies /10m /day, if extrapolated. Similarly, another peak of 1360 butterflies / 10m /5 minute was recorded in Keru of Jodhpur district on September 29th which corresponds to the 16, 320.00 butterflies /10m / Hour and 97,920.00 butterflies /10m /day. Density of swarm movement was higher near to breeding areas and declined with increased distance. Therefore, the least density of 135 butterflies /10m /5 minute was recorded in Beawar of Ajmer district. Direction of movement of butterfly swarms in general was South West. However, slight variation was also recorded in some locations (Table 1).

Ramesh *et al*. (2012) observed the North-South migration of butterflies at Kalpakkam during October and July, respectively. They considered avoidance of rain, resource competition at emergence sites and available larval host plants as the major reasons of migration. Williams (1927) indicated that the migratory tendency among

Table 1: Directional movement and density of migratory butterflies at different locations.

Date	District	Location	Butterfly movement (/10 m strip)			Direction of movement	Latitude	Longitude	Elevation (MSL)
			(Nos/5 min)	Nos/hour	Nos/day (6 hours)				
19.09.2020	Jaisalmer	CAZRI RRS	580	6960.0	41760.0	South West	26°54'56.7"N	70°54'30.04"E	238.21
	Jaisalmer	Lathi	1131	13572.0	81432.0	South West	26°57'20.6"N	71°48'56.6"E	240.00
	Jodhpur	Balesar	410	4920.0	29520.0	South West	26°23'08.6"N	72°29'59.9"E	262.00
	"	Bilara	316	3792.0	22752.0	South West	26°12'44.3"N	73°41'37.1"E	275.38
	Pali	Jaitaran	265	3180.0	19080.0	South West	26°12'02.4"N	73°55'19.3"E	297.02
	Ajmer	Beawar	135	1620.0	9720.0	South West	26°04'28.1"N	74°19'09.7"E	453.15
28.09.2020	Sirohi	Sirohi	145	1740.0	10440.0	South West	24°52'45.40"N	72°50'29.86"E	292.00
	Jodhpur	Keru	1360	16320.0	97920.0	South East	26°19'0.77"N	72°53'16.97"E	272.00
	"	Kudiyala	183	2196.0	13176.0	South East	26°19'4.38"N	72°51'23.12"E	236.00
	"	Dechu	315	3780.0	22680.0	South East	26°35'36.85"N	72°19'34.91"E	293.00
	Jaisalmer	Khetolai	230	2760.0	16560.0	South West	27°1'29.30"N	71°39'48.83"E	214.00

butterflies was predominately evolved during March-July and October-November, to avoid unfavorable climatic or weather conditions, especially North-East Monsoons (NEM) and South West Monsoons (SWM). Movements of butterflies to South West direction under present study could be the reason to avoid the onset of North East Monsoon. In best of our knowledge, this is the first report on butterfly migration in western arid region while Williams (1927) was the first who analyzed the butterfly migrations and concluded that in Kodaikanal, October flight was very definite to the South and the March and May-June flight towards the North while in Ceylon both the flights were towards the westerly quarter (*i.e*. between N.W. and S.W.).

Evershed (1910) observed southward migration of *Catopsilia* sp in Kodaikanal (TN) during October- November and remained unaffected from the wind direction. Shull (1952) reported the southerly movement of *Catopsilia* during September at Bombay Presidency which supports the present study. Bharos (2000) noted north wand migration of *C. pomona* during June 1999 in Madhya Pradesh. Larsen (1978) reported Southerly migrations of *Appias albino*, *A. libythea*, *C. pomona*, *C. pyranthe*, *C. crocale crocale*, *Phalanta phalanta* during May in Nilgiri mountains (TN) while *Atrophaneura hector* and *Pachlioptra aristolochiae* in south direction during October. Studies of Mathew and Biony (2002) are in concurrence to the present findings who reported South West Migration of five butterfly species in the Nilgiri Biosphere reserve (Kerala part) of Western Ghats. Santhosh and Basavarajappa (2017) mentioned the *Tirumala* sp and *Euploea* sp migration towards South-West during September-November in Western Ghats of Karnataka. Kunte (2005) observed swarm density of *T. septentrionis* (Butler) and *Euploea sp* in Western Ghats @ 195 butteflies /10m/5 minute which comes to 2,340/10m/ hour or 58,500/50m/day (5 hours count in a day).

Diurnal migratory pattern

Total butterflies recorded at hourly interval between 8.0 AM to 6.0 PM have been denoted the percentage of the total numbers sighted in a day. Fig (1) shows the pattern of movement during the day and density varied with different time hours. The curve of diurnal movement was more or less like bell-shaped and this trend indicated that butterflies activity was started in early hours of day (8.0 AM), attained peak around noon (12.0-1.0 PM) and then declined gradually, thus 56 % activity was around 11.0 AM to 2.0 PM. Therefore, it can be inferred that butterfly activity is greatly influenced by weather parameters, particularly temperature and sunshine hours. It was also observed that cloudy weather completely ceased the movement and regained with the appearance of bright sunshine. Observations were also made on the flying height of butterfly which indicated the butterfly movement was mainly at a height of 0.5 to 4 meter. However at one place, butterflies were crossing a flyover bridge without change in direction which may be elevated upto 10 m. In case of any obstacle, butterflies slightly deflected or increased its height but didn't change the direction.

Ramesh *et al*. (2012) also observed the maximum density during the mid day and then gradual decline. Mathew and Biony (2002) observed the peak hours of flight density between 12- 13 hrs when as many as 160 butterflies per minute were recorded which gets nearer to 9600 /hour or 57600 /day (6 hours count in a day). Bharos (2000) viewed the *C. pomona* flying at a height of 0.5- 4.0 m. Walker and Riordan (1981) stated that climatic factors including the cloud cover govern the migration. Flying bout duration generally increased with temperature and decreased with cloudiness (Cormont *et al*., 2011).

Correlation between swarm density and abiotic factors

In present study it was found that weather parameters *viz*., temp, RH, wind speed and sunshine significantly affected swarm movement. Pearson correlation was analyzed for swarm density and weather parameters, butterfly swarm density was found positively correlated with temperature (r=0.54) while negatively correlated with RH (r=0.60). Activity of butterflies started early morning, however the movement remained less distinct but with the progress of the day, it became more distinctive. Highest activity of butterflies (404 Butterflies /10m strip/5 minute) was recorded during 1.00 PM corresponding to the period when maximum temperature was 36.7°C, humidity 37 per cent and wind speed 6.3 kmph.

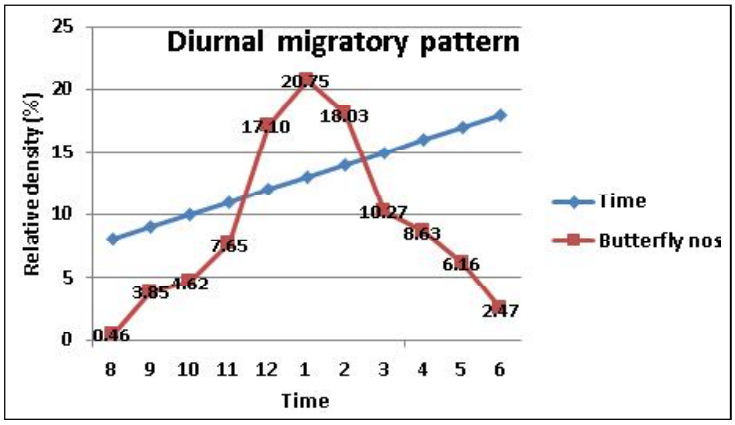

Fig 1: Butterflies migratory pattern during different time intervals.

Increase in temperature was seen to increase the activity of butterflies while decrease in humidity was found to increase the abundance of butterflies. The correlation study revealed that the sunshine hours had positive correlation with appearance and population density of butterflies. Wind speed had lesser influence on butterflies swarm. The correlation co-efficient values were presented in Table 2.

Findings of the Ramesh *et al*. (2012) corroborate the present study who found the positive correlation of temperature and wind speed with butterfly swarm. However, relative humidity and sunshine found to be negatively correlated during October which is partly in agreement with the present study. Larsen (1978) noted the direction of butterfly movement remain unaffected with the wind direction.

Nature of damage, extent of infestation and adult behavior

Large scale breeding of *Catopsilia* sp observed on senna in and around areas of Pokhran of Jaisalmer district (Fig 2). Damage was mainly due to caterpillars. Larvae of this pest found to be serious defoliator. Larval feeding resulted in denuding of plants (Fig 4a). Larvae pupated on plants and remain attached with the silken thread. About 44-96 percent infestation was recorded on senna. Female laid white color eggs on both surface of foliage. They deposited an average of 94.8 eggs per plant, of this 59.50 percent laid on upper surface while 40.50 percent on lower surface (Table 3 and Fig 3a, b, c, d). Apart from senna, pupal exuviae were also found in large numbers attached to the *ber* and other desert vegetation. Butterfly adults were also found to exhibit the puddling process through which they were imbibing nutrients from the moist soil (Fig 4b).

Chaudhary and Saravanan (2013) reported 15 to 40 eggs/plant and subsequently 5 to 35 mottled butterfly larvae / senna plant during June and September, respectively in Gujarat conditions. They also reported an infestation level of 88-100 per cent in senna. Arms *et al*. (1974) associated the mud puddling behavior with sodium salts requirement and linked more water and salts requirement during migration as one of the reasons.

Table 3 depicts last 10 years rainfall data of Jaisalmer which revealed that during 2020 rainfall received in monsoon months (238.0 mm) and in particular September month (45.60 mm) is the highest in last One decade. All the arid districts received very good rains during September month. This may be one of the reasons of outbreak which favored either the multiplication of pest or increased the foliage of the plants. Thus, caterpillars received the more amount of palatable food. Richard *et al*. (2017) found positive

Fig 2: Butterflies flying in a senna field at Pokharan (Jaisalmer).

Table 2: Correlation between swarm density and abiotic factors during September.

Time of observation in a day (29.09.2020)	Max Temperature (^{0}C)	RH (%)	Sunshine (Min/Hour)	Wind speed (Kmph)	Butterflies(Nos.) / 10m strip/5minute
0080	30.0	64	0.4	4.9	9
0090	30.5	53	1.0	6.7	75
0010	33.0	47	1.0	5.5	90
0011	34.2	43	0.9	10.3	149
0012	36.0	38	1.0	5.9	333
0100	36.7	37	1.0	6.3	404
0200	37.4	36	1.0	6.1	351
0300	37.8	33	1.0	7.1	200
0400	37.8	34	1.0	5.3	168
0500	37.8	37	1.0	3.3	120
0600	37.0	38	1.0	3.3	48
Mean	**35.29**	**41.82**	**0.94**	**5.88**	**177.00**
Coefficient of correlation (r) for popul and max temperature					0.54
Coefficient of correlation (r) for pop and relative humidity					-0.60
Coefficient of correlation (r) for popul and Sunshine (Hrs)					0.44
Coefficient of correlation (r) for popul and Wind speed (Kmph)					0.25

association between precipitation and caterpillar abundance of *Platyprepia virginalis.* Synchrony with host plant has been suggested as an important factor in the dynamics of many forest pests (Van Asch and Visser, 2007). For instance, 69% of *Rhopobota naevana* neonates die before feeding when presented with only old cranberry leaves compared to 11% on young expanding foliage. Population growth is thus five times higher if larvae hatch in synchrony with host bud burst (Cockfield and Mahr, 1993). First-instar *Zeiraphera canadensis* show dramatically lower survivorship (> 50% to < 25%) when fed on 4-5 day old white spruce foliage (Carroll and Quiring, 1994).

Fig 3: 3a. Egg, 3b. Larva, 3c. Pupa, 3d. Adult.

Host acceptance to other plants

At present, only the senna crop has been under attack from this caterpillar but with rapid changes in agro ecology and climate of the region, this butterfly pest of *C. angustifolia*, may switch over to other crops of the fabacea family. To find out the host acceptance of larvae on other crop plants, larvae of *Catopsilia* sp were fed on the leaves of *kharif* crops namely mungbean, groundnut, cluster bean, moth bean and pearl millet but the larvae didn't feed on the leaves and died due to starvation.

C. pomona reported serious pest on *Cassia fistula* and *C. angustifolia*, (Anonymous, 1995; Anonymous, 2000). Saji *et al*. (2020) reported *C. fistula*, *C. javanica*, *Senna sp*, *Ormocarpum sp, Sesbania* sp, belonging to Fabaceae and *Gnidia glauca* (Thymelaeaceae), as larval host plants of *C. pyranthe.* Since introduction of IGNP and exploitation of groundwater in last two decades, the Agro-ecology of arid regions has been tremendously changed. With this changing agro-ecology, some pests of non significance have become pests of major importance. Insect like the cetoniid beetles *Protaetia terrosa* which were very active on grasses has now been well established on cluster bean crop. *Clovia puncta* Walker established on pulses (Verma, 1979) from grasses. *Maladera insanabilis* has been established as a

Fig 4: 4a Defoliated senna plant 4b Adult butterflies imbibing nutrients from moist soil.

Table 3: Rainfall pattern in Jaisalmer during 2011- 2020.

Month	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	0.0	0.0	10.0	0.0	0.0	0.0	4.5	0.0	0	0
February	0.0	0.0	15.4	0.0	0.0	0.0	0.0	0.0	0	0
March	0.0	0.0	0.0	0.0	5.0	7.5	0.0	0.0	0	13.1
April	0.0	15.5	2.0	17.0	7.8	0.0	9.0	5.0	0	0
May	1.0	7.5	5.0	49.2	10.0	7.2	6.0	10.0	4.1	7.4
June	0.0	0.0	5.0	1.2	47.2	8.2	46.5	3.2	11	32.7
July	48.5	7.5	47.0	50.7	130.9	6.2	72.1	47.4	15	35.2
August	85.5	74.0	80.5	0.0	38.0	77.0	21.0	49.0	58.2	124.5
September	31.0	29.0	0.0	5.0	21.2	0.0	0.0	3.0	27.8	45.6
October	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0
November	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0
December	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0	0
Total	166.0	133.5	164.9	123.1	260.1	106.1	165.6	117.6	136.8	258.5

Source- ICAR-CAZRI RRS Jaisalmer.

Table 4: Extent of infestation and breeding behavior on senna crop.

Field	Plants examined	Infested plants (Nos)	% infestation	Plants	Eggs			Larva	Pupa	Total
					Upper leaves	Lower leaves	Total			
1	25	17	68	1	129	47	176	19	7	202
2	25	24	96	2	51	42	93	9	4	106
3	25	14	56	3	24	30	54	6	11	71
4	25	21	84	4	32	44	76	13	3	92
5	25	11	44	5	46	29	75	16	7	98
Sum	125	87	348	Sum	282	192	474	63	32	761
Mean	25	17.4	69.6	Mean	56.4	38.4	94.8	12.6	6.4	152
Range			44-96	Range	24-129	29-47	54-176	6-19	3-11	71-202

regular pest on several crops in the IGNP area (Verma, 1999).

CONCLUSION

Introduction of Indira Gandhi Canal and exploitation of groundwater through tube wells in last two decades has accentuated the some of the problems in desert area. One such problem is the insect- pest and diseases which are now on increase. Climatic factors in this particular case would have been played a major role in breeding in vast numbers. Present study indicated that this butterfly is breeding in immeasurable numbers in arid region. At present, only the senna crop has been under attack from this caterpillar but with rapid changes in agro ecology and climate of the region, this butterfly pest of senna, a crop of fabacea family, may switch over to other crops of the fabacea. Further more detailed studies need to be carried out to find out the host range, breeding behavior, seasonal occurrence of this insect, otherwise, this could be another big problem like locust. Therefore, there is need to keep an eye on the activity of this pest in the arid region.

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