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Bionomics and Correlation Study of *Cheilomenes sexmaculata* (Fabricius) (Coleoptera: Coccinellidae) on sap sucking pest *Aleurodicus dispersus*(Russel)

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Abstract
Cheilomenes sexmaculata (Fabricius) *is a natural enemy of various plants' sap-sucking insect pests viz. Whitefly, Aphids, Jassids, etc. This predator is an effective deterrent to sap-sucking insects and it can be used in augmentative release programs, for that requires more ecological and biological data. The main objective of this study is to inspect the development study of C. sexmaculata on the pest Aleurodicus dispersus. C. sexmaculata laid eggs in groups and hatches within 1.72 ± 0.72 days, after hatching larvae start to feed on A. disperses young stages, total larval development completed within 7.23± 2.89days, having four instars. Pupation was completed in 5.97± 0.98 days. The total lifecycle of C. sexmaculata completed 48.08 to 53.84 days. Coefficient Correlation with scatter diagram was studied concerning the population of predator C. sexmaculata, and pest A. dispersus with abiotic factors; Maximum Temperature, Minimum Temperature, Maximum Relative Humidity, Minimum Relative Humidity, and Rainfall.*

Key words:*Cheilomenes sexmaculata ,Aleurodicus dispersus, biology, predator,Coefficient Correlation.*

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I. Introduction

Biological pest control is an eco-friendly and long-term effective method, which results in natural pest control for up to a long time. Now a day's predators are artificially reared and released in the field for biological pest control. It is important to study the effect of natural factors on such biocontrol agents, so the present study has been done in the Kolhapur district. Coccinellid beetles are natural predators of sap-sucking agricultural crop pests because of their predaceous nature. These are deliberated as the most efficient and eco-friendly replacements for harmful pesticides. The main important role of Coccinellid is to control the pest naturally (Shanmugapriya 2017). *Cheilomenes sexmaculata* (Fabricius) commonly called as six- spotted zigzag ladybird is a Coccinellid predator. *C. sexmaculata* feeds on various pests including whiteflies, Aphids, Jassids, Mealy bugs, Psyllids, etc. Both adults and larval stages play important role in pest population suppuration by feeding on pest population (Omkar and Pervez, 2000). *C. Sexmaculata* can feed on a total of 39 different kinds of Arthropodan insects. (Gautam, 1989). *C. sexmaculata* have a very wide geographic distribution, host range, wide habitats, tolerance to some definite pesticides, greater searching ability, voracious larval feeding capacity, and easy to rear in the laboratory (Venkatesan *et. al.*,2006). In India, about 36 different species of aphidophagous Coccinellids are reported (Baskaran and Subramanyam, 1992). *C. Sexmaculata* recorded in all Asiatic countries (Islam and Nasiruddin, 1978). *C. sexmaculata* is predominantly found in India, Japan, China, Nepal, and Indonesia (Poorani, 2002). The development and feeding potential of Coccinellids varies with their food and changes with the environmental conditions. *Aleurodicus dispersus* Russell is a polyphagous pest, native to the Caribbean region and Central America (Russell, 1965). It is commonly known as a 'spiraling whitefly' because its eggs lay in a typical spiral pattern and it has a wide range of host plants (Kumashiro *et. al*., 1983). Besides *Cheilomenes sexmaculata* (Fab.) is an effective predator of *A. dispersus*, reported by Palaniswami *et., al.* (1995), Mani & Krishnamoorthy (1999a), Asia Mariam (1999), Muralikrishna (1999) and Geetha (2000). The present study of the life stages of the predator checked their correlation with abiotic factors and pest *A. dispursus*. It is necessary to know the probable occurrence of this pest and its native predator. Also studied was the efficiency of *C. sexmaculata* as a bio-control agent on spiraling whitefly.

II. Materials and Methods

Samples of *C. sexmaculata* with pests were collected from various habitats of the Kolhapur district of Maharashtra, India. Collected species were reared in the laboratory for biological studies and also studied coefficient correlation with abiotic factors. Samples were collected from host plants viz, Guava, Tropical almond, *Hibiscus*, Golden Champa, Karanja, and Anjeer plant which were infected with whitefly and associated predator. Samples randomly collected 10 infected leaves from different habitats of the study area; collected infected leaves kept in plastic bags, and brought into the laboratory. Further study was conducted in the research laboratory of the Department of Zoology, Shivaji University, Kolhapur, Maharashtra, from January to December 2016 to 2019. Screening of samples was done under a stereoscopic microscope and maintained in the predator sample in plastic containers and observation of life stages and development of predators on whitefly pests were recorded. The biological study of *C. sexmaculata* followed the methodology of Santha Kumar *et. al*.,(1994 &1996). The experiments were conducted under laboratory conditions at 26ºC to 28 ºC temperature and 75% to 82% RH. A Scatter plot of *C. sexmaculata* with pest and respective abiotic factors was made.

III. Results

The total developmental period of each stage of predator *C. sexmaculata* has been studied in detail on pest *A. dispersus*.

5 to 12 clusters of eggs are laid by a single mated female per day, each cluster containing about 6 to 21 eggs. The Eggs are cigar-shaped and bright yellow, near about 1.0mm x 0.3mm in length and width respectively, and they are turning black before hatching. The mean egg incubation period of *C. sexmaculata* was recorded at 1.72 ± 0.72 days. Priyadarshani and their coworkers reported 3.0 ± 0.4 days in 2016 which was reared on *Aphis craccivora* in Sri Lanka. Newly emerged larvae are dark grey. A similar observation was noted by Tank and Korat (2007). The first instar larva measures about 1.8mm in length x 0.2mm in width. The first instar was completed on an average of 1.85 ± 0.74 days. Second instar larvae are black with small spots on dorso-lateral side. Development of second instar larvae completed within 1.62 ± 0.52 days. The length and width of the larva were 4.0mm x 1.2mm respectively. Third instar larvae measure about 5.9mm x 1.3mm, dull black with yellow spots on the dorsal, they are develops within 1.78 ± 0.73 days. But when they reared on *A. craccivora* it will develop within 1.9 ± 0.5 days (Tank and Korat 2007). Fourth instar larvae are black with yellow spots on the dorsal. Developmental period noted1.98 ± 0.87days and it measures about 6.5mm in length and 1.3mm in width. Total larval development completed on an average of 7.23± 2.89 days. Full-grown fourth instar larva goes into pupation. Most of the time pupa is observed on the lower surface of the leaf of the host plant. Concave in shape, four pairs of black spots are present on the lateral surface of the abdomen, which measures about 3.7mm in length and 2.5mm in breadth. The total pupal period was recorded as 5.97± 0.98 days. The adult is moderately oval convex and shiny. Head with a black marking in the posterior half, pronotum with T - a shaped median mark, which is connected to the broad back posterior margin, elytra with two pairs of webbed markings, and at the tip present pair of black spot (Patel 1998). The overall developmental period in males is noted at 33.16± 5.16 and in females at 38.92± 4.57days. The length and breadth of the male beetle measure about 4.6mm and 3.8mm, and in females 5.9mm and 4.2mm respectively. The total lifespan of *C. sexmaculata* was completed on an average of 48.08 to 53.84 days in the climatic condition of Kolhapur district.

Table no. 01: Developmental Period of *C. Sexmaculata*

Life Stages	**Duration (Days) (Mean ± S. D.)**
Egg	1.72 ± 0.72
First Instar	1.85 ± 0.74
Second Instar	1.62 ± 0.52
Third Instar	1.78 ± 0.73
Fourth Instar	1.98 ± 0.87
Total Larval Period	7.23± 2.89
Pupa	5.97± 0.98
Adult Male	33.16± 5.16
Adult Female	38.92± 4.57

Photo A –D Developmental stages of *C. sexmaculata*on *A. dispersus*. A: Eggs of *M. sexmaculata*, B: Larval emergence, C: First instar larva, D: Second instar, E: Third instar, F: Fourth instar, G: Pupal stage, H: Adult,I: Mating of male and female *C. sexmaculata*

Table No. 02 Correlation studies between a predator*C.sexmaculatus*, pest*A. dispersus*population and abiotic factors:

Predator	**Pest/ Abiotic Factor**	**Simple Linear Equations**	**Coefficient of Determination (R^2)**	**Coefficient of correlation (r)**	**P value**	**F value**
Chilomenessex maculata	*A. dispersus*	y = 0.0082x - 0.0112	0.2069	0.455*	5.279×10^{-5}	18.5220
	Maximum Temperature	y = -0.0021x + 0.2261	0.0012	-0.035	0.7670	0.0885
	Minimum Temperature	y = -0.0293x + 0.7073	0.1819	-0.427*	0.0002	15.7892
	Maximum RH	y = -0.0054x + 0.5359	0.173	-0.416*	0.0003	14.8556
	Minimum RH	y = -0.0032x + 0.3018	0.0931	-0.305*	0.0087	7.2845
	Rainfall	y = -0.0008x + 0.1926	0.0744	-0.273**	0.0196	5.7073

1% Significant *, 5% Significant **

C. sexmaculata found a 1% significant correlation with pests when, P is 5.279 X 10– 5 and r = 0.455 and R2 is 0.2069, a simple linear equation is y = 0.0082x - 0.0112 (Figure 1). In maximum temperature, the predator observed a positive correlation and the regression equation shows y = -0.0021x + 0.2261, while R2 is 0.0012, r= -0.035, and P= 0.767(Figure2). Minimum temperature shows 1% significant level of significance, R2=0.1819, r= -0.427*, P= 0.0002 and simple linear regression was y = -0.0293x + 0.7073 (Figure 3). Maximum and minimum relative humidity shows 1% significance (P=0.0003, 0.0087) with negative correlation, linear regression equation shows y = -0.0054x + 0.5359, y = -0.0032x + 0.3018 and R2 0.173, 0.0931 r= -0.416, -0.305 (Figure 4, 5). Rainfall was negatively significant at a 5% level of significant correlation (P = 0.0196) with predator with equation y = -0.0008x + 0.1926, while R2 = 0.0744, r = -0.273 (Figure 3).

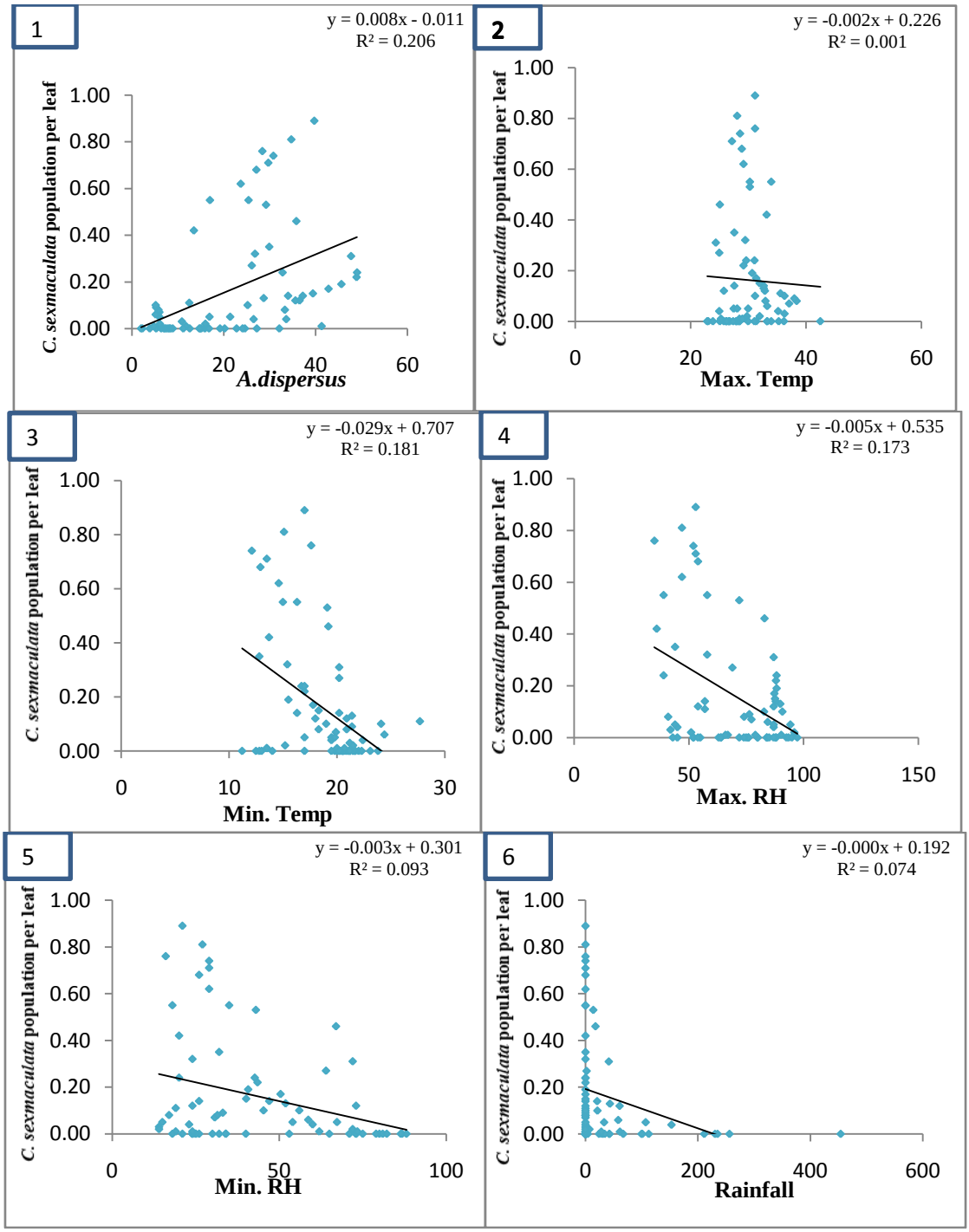

Figure 1-6: Scatter plot graphs of pest *A. dispersus*, weather parameters, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall against a predator *C. sexmaculata population* per leafpopulation.

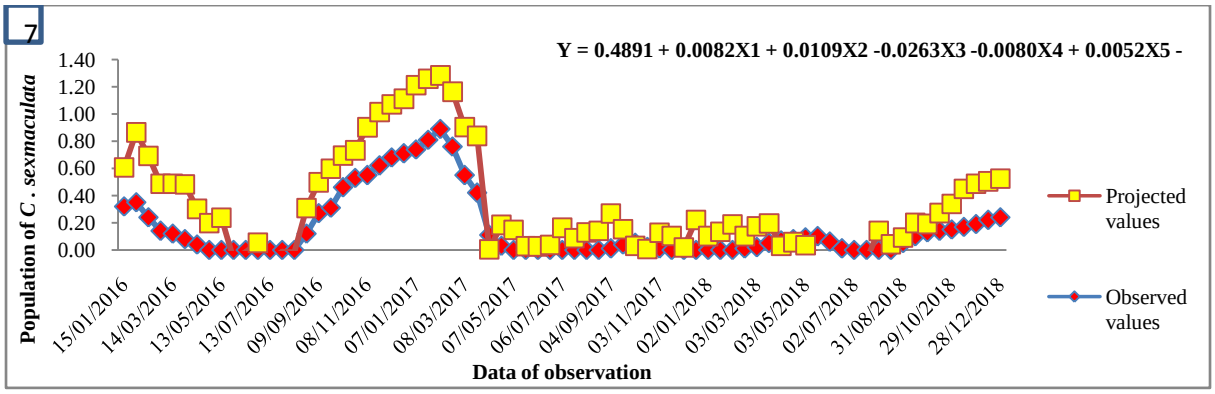

Figure 7: Correlation between seasonal incidence of *Cheilomenes sexmaculata* , pest and abiotic factors.

IV. Conclusion

C. sexmaculata is an effective natural enemy for biological control of *A. dispersus*. This predator feeds on different kinds of pests. The total lifecycle completes within 48 to 53 days while Tank and Korat (2007) mentioned the total development period of males 29.72 ± 2.20 and females 34.15 ± 2.54 days. This lifecycle information reveals the potential of *C. sexmaculata* to use as a biocontrol agent to manage the whitefly pest *A. dispersus*. Such studies would be spirited to explain further use and to check that the ladybird doesn't harm the environmental condition. Determination of the coefficient correlation of *C. sexmaculata* concerning pest A. disperses and abiotic factors indicate that predator shows a significant with pest and a positive correlation with maximum temperature and a negative correlation with minimum relative humidity and rainfall. When the pest population is too high, the predator population starts to increase and it keeps the pest population below the economic level of damage.

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