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RECORD OF NATURAL ENEMIES OF FEW BUTTERFLY SPECIES AMIDST AGRICULTURE ECOSYSTEMS OF CHAMARAJANAGAR DISTRICT, KARNATAKA, INDIA

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ABSTRACT: Field studies were carried out by following various standard methods to record the natural enemies of 19 butterfly species during Rabi and Kharif crops amidst agriculture ecosystems of Chamarajanagar District ($11^{0}40^{1}$ to $12^{0}48^{1}$ NL and $74^{0}52^{1}$ to $76^{0}07^{1}$ EL) in south Deccan plateau at southern tip of Karnataka State, India. The oviposition and pupation of butterfly species were critically observed for the parasites and predators attack. The death of egg, pupa, larva and adult butterfly species due to parasitoids and spiders was recorded. The parasitoid, *Brachymeria jambolana* (Hymenoptera: Chalcididae) was more troublesome to the pupa of *G. doson* and *E. core*. Around 25 to 27 *B. jambolana* adult individuals were collected respectively from the pupa of *G. doson* and *E. core*. Moreover spider species viz., *Selenopes*, *Zygeilla*, *Argiope*, *Hippasa*, and *Rhene* become common predators to 16 butterfly species in this part of the State. Thus, parasitoids and spiders infestation could cause loss to several insect species including protected species like *E. core*. As natural enemy's interferences is natural in the wild/open cultivated conditions, it could become one of the major reasons to reduce local butterfly diversity. Hence, there is a dire need to understand about the interaction of parasitoid species with butterfly species which are under threat and whose presence is very essential for the restoration of local biodiversity.

KEYWORDS: Natural enemies, butterfly species, agriculture ecosystem, Karnataka

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1. INTRODUCTION

Agriculture ecosystems are one of the important habitat settings for biological conservation especially for pollinators including native butterfly species (Rossi and Halder, 2010). Agriculture ecosystems are viewed as mosaics of diversified habitats sustaining high level of biodiversity. It supports local diversity with heterogeneous group of insect species (Dover and sparks, 2000) amidst changing environment in cultivated ecosystems (Pullin, 1995). However, there are numerous reasons for pollinators decline, of which habitat loss, habitat fragmentation and natural enemies are major ones (Goulson et al., 2008) amidst agriculture ecosystems. Butterfly species are affected by their natural enemies such as predators, parasites and parasitoids. Around 95% individuals in every butterfly species are dying before they attain adulthood due to parasitic infestation, predation and enemies attack in agriculture ecosystems (Kunte, 2000). Parasitoid larvae live in or on their host body and finally kill its host generally. About 10% insects are parasitoids (Eggleton and Belshaw, 1992) feed on the vital organs of different aged caterpillars of various butterfly species. Soon after pupation, parasitoids emerge from the pupa by killing its host (Lewis, 1946). Several researchers have reported on different butterfly species mortality due to various parasitic infestations. Muggeridge (1943) has explained the role of *Pteromalus puparum* (American breed) as successful in controlling certain agriculturally harmful butterflies in New Zealand. Lewis (1946) has reported the predatory Pentatomid bug, *Cantheconidea furcellata*, reduviid bugs, birds, spiders, sphecids and Chameleons role while controlling the harmful butterfly species larvae in Thailand. Atwal (1964) has identified the young caterpillars of *Papilio domelus* attacked by the yellow wasp, *Polistes hebreus*, praying mantis, *Creobrator gemmatus* and different spider species. The pupae of butterfly species were parasitized by *Pteromalus* species and eggs by hymenopteran insect in USA. Ohsaki and Sato (1994) have explained the intrinsic quality of potential food plants choice that can prevent parasitoid infection to *Pieris* species. Benson et al. (2003) have reported that in late 19th century, Braconid parasitoids were used for biological control of *Pieris rapae* in North America. Stefanescu et al. (2003) have reported Pieried butterflies in England suffered due to braconid parasitoids and the parasitoids did act as an important pest controlling agents. Stefanescu et al. (2003) have also reported the complexity of *Iphiclides podalirius* (Lepidoptera: Papilionidae) due to parasitoid infection in north-east Spain. Oberhauser et al. (2007) have reported *Lespesia archippivora* parasitoid infection on monarch butterfly larvae in USA. Further, Ankola et al. (2011) have observed female-biased sex ratio distortion in *Taliada nyseus* and its population was dwindling. Bartel et al. (2011) have reported the migrating monarch butterflies are transmitting protozoan parasite, *Ophryocystis elektroscirrha* in North America and seasonal migration can affect parasite

transmission in wild animal populations and inturn likely to influence interaction between animals and their parasitoids among wild animal population. While, *Brachymeria* species (Hymenoptera: Chalcididae) and *Pteromalus puparum* (Hymenoptera: Pteromalidae) as pupal parasites in Japan. Saradar et al. (2014) have reported the parasitic pupa of *Papilio demoleus* by *Pteromalus puparum* and eggs of *P. demoleus* were infected by *Trichogramma* and *Telenomus* species. Sardar et al. (2014) have reported *Oencyrtus malayensis* (Hymenoptera: Encyrtidae) and *Tetrastichus* species (Hymenoptera: Eulophidae) are the kinds of egg parasites in Thailand. Furthermore, Krishnamurthy and Singh (1986) have recorded more than 75% eggs and larva of *Papilio domoles* and *P. polytes* species were parasitized by *Trichogramma chilonis* and *Telenomus* species. Mani and Krishnamurthy (2000) have recorded one of the potential braconid larval parasitoids, *Distatrix papailionis* (Apanteles) that cause 73% parasitization on citrus butterflies (*Papilio* sp.) in India. Later, Gupta and Haldhar (2012) have reported the pupa of *Graphium doson* (Lepidoptera: Papilionidae) infestation on pupal parasite, *Brachymeria jambolana* (Hymenoptera: Chalcididae) from Bangalore. Guptha et al. (2012) have reported pupae of Common wanderer, *Pareronia valeria* and Common jezebel, *Delias eucharis* infested by *Brachymeria indica* in India. Gupta and Pereira (2012) have reported a new species, *Glyptapanteles hypermnestrae* from Maharashtra. They bred from parasitized larvae *Elymnias hypermnestra* (Lepidoptera: Nymphalidae). The hymenopteran parasitoids, *Apanteles folia* (Braconidae: Microgastrinae) and *Brachymeria indica* (Chalcididae) were for first time reported their parasitization on the larvae of *Arhopala amantes* (Lepidoptera: Lycaenidae) and pupae of *Pareronia valeria* (Lepidoptera: Pieridae) respectively. Guptha and Mandal (2005) have provided the information about host association and brief taxonomical description about 16 species of parasites which belong to Encytridae, Eulophidae, Chalcididae, Eucharitidae, Aphelinidae and Pteromalidae from Andaman and Nicobar Islands in India. Sureshan (2013) has reported the parasitization of *Pteromalus puparum* on Papilio polytes. Ahmed et al. (2014) have reported the endoparasite, *Sturmia convergens* and its life cycle in the pupa of *Danaus chrysippus* by taking 38.1 ± 2.02 days and these published reports of few butterfly species population is under check due to natural enemies at different part of India. Among all, *Brachimeria* species is considered as one of the biological controlling agents, cause high mortality of few butterfly species in agriculture ecosystems. Reports on such observation in Chamarajanagar District are not available. Hence, the present investigation was conducted amidst agriculture ecosystems.

2. MATERIALS AND METHODS

Study area: Chamarajanagar District lies at $11^{0}40^{1}$ to $12^{0}48^{1}$ N longitude and $74^{0}52^{1}$ to $76^{0}07^{1}$ E latitude with an area of 5,101 Km2 in south Deccan plateau at southern tip of Karnataka State (Kamath, 2001; Harish, 2011). The altitude varies from 600 to 800 MSL. The District has partly maidan area along with undulating and mountainous topography accompanied by lofty mountain ranges covered with 48.4% forest area on total land mass of the District (Anonymous, 2010). March and April months experience highest temperature (400C) while December and January indicated lowest temperature (90C). The relative humidity (RH) ranges from 60 to 80% during morning hours and 20 to 70% in the evening with an average rainfall 816.1mm. The wind speed ranges from 8.4 to 14.1Km/h. Further, only 33% land is utilized for agriculture activities. Since, agriculture is the main source of income in this District; farmers are depended on both Rabi and Kharif crops (Anonymous, 2010).

Methodology: The sites which are used for oviposition and pupation by 19 butterfly species were critically observed for the parasites and predators attack. During the field survey death of egg, pupa, larva and adult butterfly species (Table 1) due to different natural enemy's viz., parasitic wasps, spiders and parasitoids were recorded by following standard methods. The pupa suspected to be infested by parasitoids or predators were collected in the field and brought to the Laboratory for observation. The collected samples (e.g. eggs, larva and pupa) were kept in normal laboratory conditions with 26-28^{0}C. temperature and 40-70% relative humidity with normal photo period. Observation was made frequently for parasitic activity as per Mani and Krishnamurthy (2000), Guptha et al. (2012) and Gupta and Pereira (2012). Moreover, the parasitized pupa of *G. doson* and *E. core* on *Michelia champaca* and *Nerium* plants respectively were collected from agriculture ecosystem and brought to the laboratory for further studies. The development of embryo of parasite inside the pupa on the host plant was preserved until emergence of adults and was identified as *Brachymeria jambolana* as per Joseph et al. (1973), Narendran (1989) and Gupta (2010). Collected data was complied and statistically analyzed as per Saha (1992).

3. RESULTS AND DISCUSSION

The egg, larva and pupal parasitoids and enemies of different butterfly species were recorded at different agriculture ecosystems of Chamarajanagar District (Plates 1, 2 and 3). The *Telenomus* species was identified as an egg parasite of *Papilio polymnestor* and recorded its parasitization on egg by making holes on the egg shell and destroying the egg contents (Plate 2). Further, larva of *Papilio demoleus* was infested with a *Brachymeria* species and large number of emerged cocoons of *Brachymeria* was found attached on to the ventral side of 4th instar larva (Plate 1 [A]). The pupa of

Catopsilia pyranthe, *Graphium agamemnon*, *Danaus chrysippus*, *Pachilopta aristolochiae*, *Papilio polytes* and *Euploea* core were infested by *Brachymeria* species and *Pteromalus puparum* parasites (Plate 1 [B 1 to 6]). The pupa of *G. agamemnon*, *D. chrysippus* and *E. core* showed hole on their pupal case (Plate 2 [B 2, 3 & 6) due to the emergence of *Brachymeria* sp. Pupa of *P. aristolochiae* and *P. polytes* were infested by *Pteromalus puparum*. Further, few spiders species namely *Selenopes*, *Zygeilla*, *Argiope*, *Hippasa* and *Rhene* species were acted as natural enemies to 16 species if butterflies, which belong to four families (Table 1). Moreover, per cent death of butterfly species due to parasitoids and spiders attack is shown in Fig. 1. Furthermore, in the parasitized pupa of *G. doson* and *E. core* 25 and 27 individuals were collected respectively (Plate 3 [1 to 3]) and they were identified as *Brachymeria jambolana* (Hymenoptera: Chalcididae) (Plate 3 [4 & 5]).

DISCUSSION

Reporting *Brachymeria jambolana* as one of the parasitoids on *G. doson* and *E. core* species is the first report in this part of the State. *G. doson* and *E. core* are distributed commonly at agriculture ecosystems of Chamarajanagar District. Since, *E. core* species is protected under Indian Wildlife (Protection) Act, 1972, understanding its natural enemies or parasitoids is very much essential to conserve this species amidst agriculture ecosystems. Similar types of studies were made on *Brachymeria jambolana* parasitization on *G. doson* at Bangalore and *Brachymeria indica* feeding on pupa of *Pareronia valeria* on *Vitex negundo* at Maharashtra by Gupta and Haldhar (2012) and Guptha et al. (2012). Distribution of *Brachymeria* species was reported from other part of Karnataka, Kerala, Meghalaya, Tamil Nadu and also from Bangladesh and Indonesia. However, present study provided an insight about the *B. jambolana* one of the known parasitoids causing much damage to the G. doson and E. core population in Chamarajanagar District. *B. jambolana* is an endo-parasite, not only parasitizes on Lepidopteran larva (Joseph et al., 1973, Gupta, 2010 and Guptha and Pereira, 2012), but also other insects which belongs to Orthoptera (Acrididae), Diptera and Coleoptera distributed in India, Bangladesh and Indonesian (Guptha and Haldhar (2012). Therefore, *B. jambolana* infestation could cause loss to several insect species including protected species like E. core. Further, predatory activity of spiders on butterflies shouldn't be under estimated. As spiders interferences is natural in the wild/open cultivated conditions, considerable numbers of butterflies are dying before they reach an adult hood due to spiders attack. It could further damage the butterfly population and reduce their diversity. Luckily, unharmed few adult butterflies would escape from predation by natural enemies would migrate to the safe and suitable place to lay their eggs and continue their generation. Notwithstanding to this, the beneficial effects of certain natural enemies shouldn't be ignored. In this regard there are reports about few parasites, parasitoids and predators as biological agents while

controlling certain insect pests at agriculture ecosystem. Shelton et al. (2002) have recorded *P. puparum* that has 44.4% pupae of *P. rapae* and its maximum parasitism rate was 31% in New York. It has effectively reduced the insect pest's pressure under field conditions (Wold-Burkness et al., 2005). Although, *Graphium agamemnon*, *Pachilopta aristolochiae* and *Euploea core* were suffered with pupal parasitoid and Papilio polytes infested by larval parasitoids. These species belong to Papilionidae family which feeds mainly on Rutaceae members (Kunte, 2000). Since, citrus plant species are one of the major commercial crop plants in the family Rutaceae, their pests control is important from the farmer's point of view. Of course, certain parasitoids did act as biological controlling agents to control pest population amidst agriculture ecosystems, but at the same time protected species like *E. core* survival shouldn't be under estimated in agriculture fields. As *E. core* is enlisted as threatened species, *G. doson* is another important species, their presence is very essential in agriculture ecosystem to maintain local biodiversity. Because, these species may be useful to other organisms whose survival may be linked with many food chains and food webs at different trophic levels. Thus, there is a dire need to understand about the usage of parasitoid species as general biological controlling agents at agriculture ecosystems where, certain species are under threat and whose presence is very essential for the restoration of local biodiversity.

4. CONCLUSION

The parasitoid species are very much important in agriculture an ecosystem there is a dire need to understand their diversity, distribution and host range in relation to locally available butterfly species. On this line, further in depth studies are required.

CONFLICT OF INTEREST

The authors declare that no competing financial interests exist.

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SUPPLEMENTARY FILES

Table 1. Mortality of few butterfly species due to natural enemies

Family	Sl. No.	Butterfly species		Natural Enemies	
		Common Name	Scientific Name	Parasitic Infestation	Spiders
Hesperiidae	1.	Bush Hopper	*Ampittia dioscorides* Fabricius	-	+
	2.	Chestnut Bob	*Iambrix salsala* Moore	-	+
	3.	Common Awl	*Hosora badra* Moore	-	+
Lycaenidae	4.	Angled Pierrot	*Caleta caleta* Hewitson	-	+
	5.	Common Cerulean	*Jamides celeno* Cramer	-	+
	6.	Dark Grass Blue	*Zizeeria lysimon* Hübner	-	+
	7.	Grass Jewel	*Freyeria trochylus* Freyer	-	+
	8.	Lesser Grass Blue	*Zizeeria otis* Fabricius	-	+
	9.	Tiny Grass Blue	*Zizula gaika* Trimen	-	+
Nymphalidae	10.	Blue Pansy	*Junonia orithya* Linnaeus	-	+
	11.	Common Four ring	*Ypthima huebneri* Kirby	-	+
	12.	Common Indian Crow	*Euploea core* Cramer	+	+
	13.	Lemon Pansy	*Junonia lemonias* Linnaeus	-	+
	14.	Plain Tiger	*Danaus chrysippus* Linnaeus	+	+
Papilionidae	15.	Blue Mormon	*Papilio polymnestor* Cramer	+	-
	16.	Common Mormon	*Papilio polytes* Linnaeus	+	-
	17.	Tailed Jay	*Graphium agamemnon* Linnaeus	+	-
Pieridae	18.	Common Emigrant	*Catopsilia pomona* Fabricius	+	+
	19.	Small Salmon Arab	*Colotis amata* Fabricius	-	+

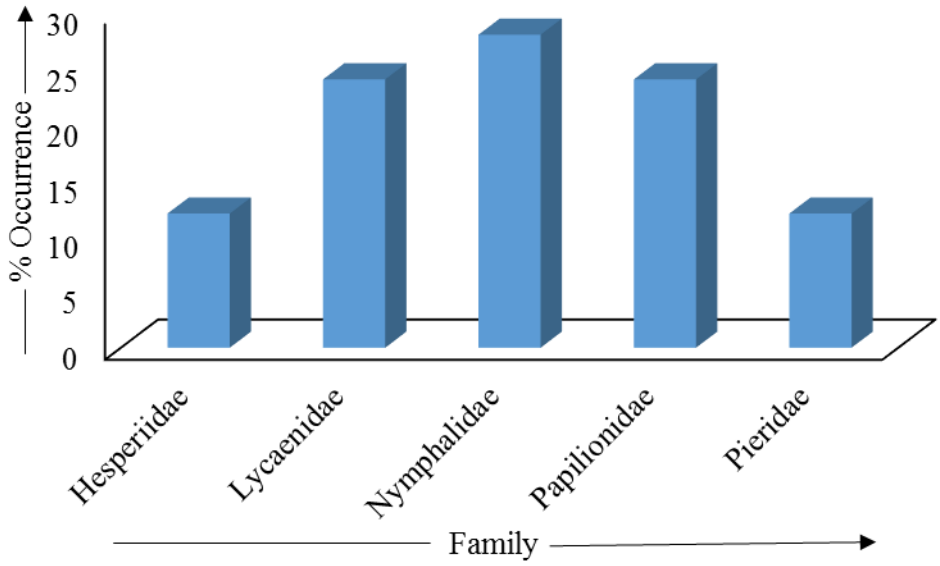
Note: + = Yes; - = No.

Table 2. Mortality of butterfly species due to natural enemies

Sl. No	Butterfly family	No. of dead butterfly species recorded		Total
		Parasitic infestation	Spider species	
1.	Hesperiidae	-	3	3
2.	Lycaenidae	-	6	6
3.	Nymphalidae	2	5	7
4.	Papilionidae	3	3	6
5.	Pieridae	1	2	3
Total		6	19	25
Mean ± SD		1.20 ± 1.30	3.80 ± 1.64	5.0 ± 1.87
'F' value		7.68*		-

Note: * Value is significant at 5% level.

Fig. 1. Per cent mortality of different butterfly family members due to natural enemies



A. *Papilio demoleus* larva infected by parasitoid wasp cocoon

1. *Catopsilia pyranthe* 2. *Graphium agamemnon* 3. *Danaus chrysippus*

4. *Pachliopta aristolochiae* 5. *Papilio polytes* 6. *Euploea core*

B. Pupa of different butterfly species showing parasitic infection

1. *Colotis amata* 2. *Caleta caleta* 3. *Catopsilia pomona*

B. Adult mortality due to different species of spiders

Plate 1. Butterflies infestation by predators and parasitoids recorded at agriculture ecosystems of Chamarajanagar District

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1. Egg

2. Parasite invading the egg

3. Parasite feeding on egg

4. Complete destruction of egg

e. Egg parasite - *Telenomus* species

Plate 2. Parasitization of *Papilio polymnestor* egg by *Telenomus* species

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1. Parasitic wasp coming out of *Graphium doson* pupa

2. Pupa of *Euploea core* showing parasitic infection

3. Disected pupa of *Euploea core* and number of parasites collected in a single pupa

4. *Brachymeria jambolana* identified inside *Euploea core* pupa

5. *Brachymeria jambolana* identified inside *Graphium doson* pupa

Plate 3. Pupa of *Euploea core* and *Graphium doson* infested by *Brachymeria jambolana*