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Diversity and bio-control potential of the genus Diadegma Forster (Hymenoptera: Ichneumonidae) From Western Maharashtra

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ABSTRACT

The genus *Diadegma* Forster (Hymenoptera: Ichneumonidae) contain 201 species from all over the world. Hosts of this genus include 438 species, and 53 families in five orders and acts as potential biocontrol agents of several insect pests. In recent days, there is tremendous pressure of pesticides on various agroecosystems, leading to very serious problems. Therefore, hopping the maximum utility of the genus *Diadegma* in biological control of insect pest, the present work was carried out. A total of 10 species of the genus *Diadegma* namely *D. trichoptilus* Cameron, *D. argenteopilosa* Cameron, *D. trochanterata* Morley, *D. fenestralis* Holmgren, *D. insularae* Cameron, *D. varuna* Gupta, *D. ricini* R. & K, *D. semiclausum* Hellen, *D. vulgari* Morley and *Diadegma* sp. were prevalent in Western Maharashtra and found controlling Lepidopterous pests viz, *Exelastis atomosa* Walsingham, *Spodoptera litura* Fab , *Dichocrocis punctiferalis* Guene, *Helicoverpa armigera* (Hubn), *Phthorimaea operculella* (Zeller), *S. litura, Achea janata* Linnaeus, *Plutella xylostella* (L.), *Spodoptera exigua* (Hubn.) and *H. armigera* causing mortalities 21.00%, 62.00%, 46%, 35.5%, 43.50%, 22.50%, 48.00%, 50.30%, 28.00%, and 20.00 % respectively in them. The life cycle duration was ranged from 14.00 days to 18.50 days in the genus *Diadegma*. *D. argentiopilosa, D. semiclasum, D. ricini* and *D. Insularae* were potential biocontrol agents of lepidopterous pests found in Western Maharahtra. Some parasitoids of this genus were hyperparasitized by *Brachymeria* sp, *Paraphylex* complex, Eulophids, Eurytoma spp, *Diagepletidea* sp. and acted as limiting factor for biocontrol potential of parasitoids in the region.

Keywords: Diversity, genus *Diadegma,* biocontrol potential.

INTRODUCTION

The genus *Diadegma* was erected by Forster in 1869 which belongs to order Hymenoptera and family Ichneumonidae and acts as potential biocontrol agents of several insect pests. The genus *Diadegma* contain 201 species from all over the world (Yu & Horstmann, 1997). Hosts of this genus include 438 species, and 53 families in five orders namely Coleoptera (phytophagus), Diptera, Hymenoptra (phytophagus, predators, and parasitoids), Lepidoptera (phytophagus, predators/flower suckers) and Trichoptera (scavengers). Twelve *Diadegma* species are known to occur in more than one geographical regions (Talekar & Shelton 1993). In recent days, there is tremendous pressure of pesticides on various agroecosystems, leading to very serious problems such as water, air and soil pollution, health hazards, killing of beneficial insects like paraisitoids, predators and pollinators; pest resistance, pest resurgence, secondary pest outbreak, destruction to ecocycles, etc. The above facts clearly indicates that there is need to find out solution for pesticidal use in pest management programmes. Biological control if works, can solve the permanent problem of pest control and is ecofriendly. Therefore, hopping the maximum utility of the genus *Diadegma* in biological control of insect pest, the present works was carried out.

Review of literature indicates that the genus *Diadegma* has been studied with respect to their identity and utility in biological control programmes by

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several workers. Noteworthy among them refer to Ayyar (1927), Rao(1953), Townes *et.al* (1961), Forster (1968), Gupta (1974), Nikam and Basarkar (1976), Sathe (1986, a,b 1987 a,b, 1988, 1990, 1992), Sathe and Nikam (1983), Sathe *et.al* (1987,2003), Abbas (1988), Poelking (1992), Fitton & Walker (1992), Yang *et.al* (1993), Amend & Basedow (1997), Sathe and Dawale (2001), Kwon *et.al* (2003), Wagener *et.al* (2004), Wang *et.al* (2004), Winkler *et.al* (2006), Huang *et.al* (2008) Khatri *et,al* (2009), Rondon (2010) , Sathe (2014, a,b, 2015), Sathe & Chougule (2014), etc

MATERIAL AND METHODS

Diversity of the genus *Diadegma* was studies from Western Maharashtra by collecting larvae of different species of Lepidopterous pests. The larvae collected from the field were reared on their respective crop plant parts in the laboratory (27 ± 1° c, 75-80 % RH and 12 hr photoperiod) for screening *Diadegma* species as parasitoids. The pests, parasitoids and crops have been identified by consulting appropriate literature cited in references. Biocontrol potential of the different species of *Diadegma* have been studied by percent mortalities caused by the parasitoids in pests which was noted by collecting the pest larvae and screening the larvae for parasitoids out of 100 individuals. On the basis of per cent mortality biocontrol potential have been studied at field conditions. Natural enemies of *Diadegama* also have been reported from the region by collecting field cocoons of the parasitoids which were parasitised by heperparasitoids.

Life cycle in parasitoids was studied in the laboratory by exposing respective larval stages of hosts of 4-day old for 2 hours, for parasitization. The parasitized hosts were reared separately in plastic containers for further development. The parasitized host larvae were dissected for each day from oviposition time for collecting developing stages of parasitoids, and incubation, larval and pupal periods of development were noted. The, records of hosts have been made by consulting appropriate literature. Distributional records of parasitoids have been made by collecting and rearing parasitized host larvae from the fields for screening parasitoids.

RESULTS

Results are recorded in table 1 and figures 1-9. A total of 10 species of the genus *Diadegma* namely *D. trichoptilus* Cameron, *D. argenteopilosa* Cameron, *D. trochanterata* (Morley), *D. fenestralis* Holmgren, *D. insularae* Cameron, *D. varuna* Gupta, *D. ricini* R. & K, *D. semiclausum* Hellen, *D. vulgari* (Morley), and *Diadegma* sp. were prevalent in Western Maharashtra which were found controlling various Lepidopterous insect pests viz, *Exelastis atomosa* Walsingham, *Spodoptera litura* Fab , *Dichocrocis punctiferalis* Guene, *Helocoverpa armigera* (Hubn), *Phthorimaea operculello* (Zeller), *S. litura, Achea janata* Linnaeus, *Plutella xylostella* (L.), *Spodoptera exigua* (Hubn.) and *H. armigera* causing mortalities 21.00%, 62.00%, 46%, 35.5%, 43.50%, 22.50%, 48.00%, 50.30%, 28.00%, and 20.00 % respectively in them. The life cycle completion range in the species of the genus *Diadegma* was from 14.00 days to 18.50 days. Potential biocontrol agents of lepidopterous pests found in the region were *D. argentiopilosa, D. semiclasum, D. ricini* and *D. Insularae* (table-1). Some *Diadegma* species were hyper-parasitized by Eulophids (Eulophidae), Eurytoma spp (Eurtomidae), *Diagepletidea* spp (Ichneumonidae), *Brachymeria* spp (Chalcidae) and acted as limiting factor for biocontrol potential.

DISCUSSION

Sathe (1992) reported natural enemies for 30 lepidopterous insect pests from Hymenoptera order belonging to the families mostly, Ichneumonidae and Braconidae. The very prominent genus found in Maharashtra was *Apanteles* from the family braconidae and from Ichneumonidae the genus *Campoletis*. According to Sathe and Chougule (2006) *Campoletis chlorideae* (Uchida) and *Trichogramma* spp were potential biocontrol agents of *H. armigera* in Western Maharashtra. *C. chlorideae* parasitized 52 % larvae of *H. armigera* in the region while, *D. fenestralis* caused 13% parasitism in second instar larvae of the same pest. Sathe & Dawale (2001) studied the morphology and biometry in immature stages of *D. argenteopilosa*. They reported 3,3,1,1,1 & 6 days as developmental periods for first, second, third, fourth and fifth instar and pupa respectively.

Sathe (1987) recorded natural enemies for *S. litura* from Kolhapur region of India for suppression of its population. He noted 60 % and 20% mortalities in the second instar larvae of *S.litura* due to *C. chlorideae* and *D. argenteopilosa* respectively. While, Sathe *et.al* (1987) found 80% mortality in *S. exigua.* due to parasitism by *C. chlorideae.* They also reported *D. argenteopilosa* and *D.vulgaris* causing mortalities in the same pest up to certain extent. Sathe (1988) reported *D. trichoptilus* completing its development from egg to adult within 17 days on the host *E. atomosa* when *Cajanus cajan* L. young pods were provided as food for the host and causing 21.00% mortalities in pest species. He also studied life tables and intrinsic rate of increase in *D. trichoptilus* (Sathe, 1987b). Nikam and Basarkar (1976) studied the biology of *Diadegma* sp. on second instar larvae of *H. armigera* by providing gram leaves to host. They noted that the parasitoid completed its life cycle from egg to adult within 12 to 13 days. In the present study, all species of the genus *Diadegma* showed 5 larval instars, and were larval, solitary, endoparasitoids and completed their life cycles ranging from 14.00 days to 18.5 days. But acted on very good biocontrol agents of polyphagous pests such as *H. armigera, S. litura* and *S. exigua* and also as

specific hosts like *E. atomosa, A. janata, D. punctiferalis, P. operculella, P. xylostella, etc.*

According to Wagener etal (2006) adult *Diadegma* females parasitized the larvae of various lepidopterous species. The host range was restricted to few species such as in *D. semiclausum* that was known to parasitize Lepidoptera of the family Plutellidae (*P. xylostella, Prays oleae* Bernard and *Prays citri Millere).* However, the host range of *D. blackburni* was with several species from eight different families *viz, Crambidae, Gelechidae, Geometridae, Oecophoridae, Pterophoridae, Pyralidae, Scythrididae and Tortricidae.* In the present study the species of *Diadegma* were species specific. The super family *Tineoidea* was also suitable hosts for the genus *Diadegma* (Bonko *et.al* 2002). Some species of the genus *Diadegma* in particular *D. inslularae* and *D.semiclausum* have gained economic importance as biological control agents of *P .xylostella* and are therefore, the best known and well examined species of the genus *Diadegma*.

According to Wang *et.al* (2004) *D. semiclausum* was the dominant parasitoid of *P. xylostella* during the winter in southern Queenland accounting for 95% of all parasitoids collected. They further noted that *D. semiclausm* wasps became active around 08:30 in the morning and soon were observed to emigrate from the source field into the experimental plots. In the cabbage field experiments, the number of wasps observed per hour increased over time during the day. Parasitism of *P. xylostella* larvae by *D. semiclausm* was higher in the uncaged than the open cage treatment. The low parasitism on the sentinel plants was due to the lack of a high degree of parasitoid aggregation relative to on the high host densities.

Active aggregation on parasitoids was noted in many studies (Waage, 1983, Waage and Keller, 2002,

Table-1. Diversity, Life cycle, hosts, distribution and bio-control potential of *Diadegma* spp. from Western Maharashtra

Sr.No.	Species	Life cycle duration	Hosts	Distribution	Biocontrol potential by % parasitism/ mortality
1.	*Diadegma trichoptilus* Cameron	17 days	*Exelastis atomosa* Walsingham	Western Maharashtra, Marathwada, Vidarbha	21.00
2.	*Diadegma argenteopilosa* Cameron	18 days	*Spodoptera litura* Fabricius	Western Maharashtra, Marathwada, Vidarbha	62.00
3.	*Diadegma trochanterata* (Morley)	18.5 days	*Dichocrocis punctiferalis* Guene	Western Maharashtra, Marathwada, Vidarbha	46.00
4.	*Diadegma fenestralis* Holmgren	14.00 days	*Helicoverpa aemigera* (Hubner)	Western Maharashtra, Marathwada, Vidarbha	35.50
5.	*Diadegma insularae* (Cameron)	16.00 days	*Plutella xylostella* (Linnaeus)	Western Maharashtra, Marathwada, Vidarbha	43.50
6.	*Diadegma ricini* R. & K.	16.5 days	*Achea janata* Linnaeus	Western Maharashtra, Marathwada, Vidarbha	48.00
7.	*Diadegma* sp.	15.00 days	*Helicoverpa armigera* (Hubner)	Western Maharashtra, Marathwada	20.00
8.	*Diadegma semiclausum* Hellen	16.00	*Plutella xylostella* (L.)	Western Maharashtra	50.30
9.	*Diadegma varuna* Gupta	18.00	*Spodoptera litura* (Fab.)	Western Maharashtra, Marathwada	22.50
10.	*Diadegma vulgari* (Morley)	17.00	*Spodoptera exigua* (Hubn.)	Western Maharashtra, Marathwada,	28.00

etc). The aggregation response was identified as an important factor which has contributed to host regulation (Ives *et al,* 1999). According to Hassel (1982) and Lessells (1985), behavioural and physiological limitations of phoraging parasitoids lead non density dependence in parasitism and a high degree of aggregation was necessary to generate direct density dependent parasitism by *D semiclausum.*

Figure-1. Gram field

Figure-2. *H. armigera*

Figure-3. *H. armigera* damage

Figure-4. *Diadegma* sp. (male)

Figure-5. *S. litura*

Figure-6. *D. argentiopilosa* (mating)

Figure-7. *D. fenestralis* – cocoon

Figure-8. *D. trichoptilius* – cocoons

Figure-9. *D. insularae* – cocoon

Newly emerged *D semiclausum* females did not showed mature eggs being a synovigenic species (Wang & Messing, 2003). Thus, parasitoid required at least 48 hr to achieve maximum matured egg load. While, Jervis *et al* (2005) suggested that a starved *D semiclausum* females were able to develop and mature some of the eggs, suggesting that it is an autogenesis species. However, when fed with honey solution, females produced significantly more eggs within 48 hr. Thus, food supply can stimulate egg maturation in the species. Therefore, ethological studies like mating, oviposition and adult emergence have tremendous importance (Sathe, 2014).

Fitton and Walker (1992) and Delvare (2004) mentioned that *D semiclausum* and *D. fenestrale,* both with a palearctic distribution, were difficult to distinguish by morphological characters and therefore genetic characterization have been made. DNA barcoding sequencing is therefore essential part of identification of the species of the genus *Diadegma* from Indian origin as there is much more diversity in this group.

According to Sathe (2014 b) *S. litura* has occurred on mulberry from August to February. The caterpillars damaged shoots and leaves by defoliating. The pest was controlled by releasing 1,50,000 *Trichogramma evanescens minutum.* Other effective parasitoids recorded from Western Maharashtra were *D. argenteopilosa* and *C. chlorideae* causing considerable mortalities in second instars of the pest. Similarly, a braconid *Meteorus dichomeridis* has also effectively controlled *Spilosoma obliqua* Walk larvae on mulberry ecosystem by releasing this parasitoid 100000/ha/week as per the need (Sathe, 2014 b).

Many Ichnemonids are widely used in biological pest control (Sathe, 2015 a). The genus *Diadegma,* as Ichnemonids found to be excellent source of biological pest control for several insects pests. Therefore, they should be surved, identified, mass reared and utilized in biological pest control programmes. However, the ideal parasitoid biocontrol agent should have following desirable attributes for its use in pest control.

1. Efficient host searching ability
2. Superior parasitism
3. Better synchronization of life cycle with its host
4. Amenability to laboratory production.
5. Better temperature tolerance capacity.
6. High degree of host specificity
7. Good adoption to survive under field conditions, etc.

Many species of *Diadegma* shows above said features hence, they have great practical potential in future.

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Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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