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KAIROMONAL EFFECT OF *CORCYRA CEPHALONICA* STAINTON AND THEIR INFLUENCE ON THE PARASITIC AND PREDATION POTENTIAL OF *TRICHOGRAMMA CHILONIS* ISHII AND *CHRYSOPERLA ZASTROWI SILLEMI* (ESBEN-PETERSON) AGAINST EGGS OF *SPODOPTERA LITURA* (FAB.)

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ABSTRACT

The present study concentration (0.1 % = 1000 ppm) of the hexane extracts of male and female whole body and larval wash of host *Corcyra cephalonica* Stainton with *Trichogramma chilonis* Ishii and *Chrysoperla zastrowi sillemi* (Esben-Peterson) revealed their kairomonal activities under *in vitro* condition. Treating irradiated eggs of *Spodoptera litura* (Fab.) with hexane extract of adult female whole body of *C. cephalonica* (1000 ppm) recorded the parasitization of 13.24 per cent by *T. chilonis* on third day after inoculation which increase from 49.73 to 70.66 per cent on fifth and seventh day after inoculation and they were 5.14, 16.72 and 28.34 per cent when the eggs were treated with hexane alone on third, fifth and seventh days after inoculation, respectively. Maximum emergence (67.84%) was observed with *C. cephalonica* female whole body extract followed by male whole body extract (56.33%). The highest predation by *C. zastrowi sillemi* on hexane extract of *C. cephalonica* female whole body treated eggs of *S. litura* was recorded (69.14%) whereas it was 29.43 per cent in hexane treated eggs, these are the results shows that *C. cephalonica* female whole body having high kairomonic impact it may be used for future biological control programme.

INTRODUCTION

Chemical ecology is the science that addresses the role of chemical cues in the interaction of organisms with their environment. The most important factors mediating the location of a host are semiochemicals through different sources. Number of chemicals released from hosts, host secretions, hosts by-products and associated organisms influence the behaviour of natural enemies. Foraging female insect parasitoids use these chemical cues extensively to locate, identify and exploit their host in different eco-system (Alhmedi *et al*., 2010; Penaflor *et al*., 2012). Many types of stimuli influence the habit location and host selection behaviour of parasitoids and predators among which the semiochemicals play a major role (Kumar and Ambrose, 2014; Joachim and Weisser, 2015). Similarly, host insects also contain saturated long chain hydrocarbons on their body surfaces. The surface hydrocarbon compositions are species specific in insects (Lockey and Metcalfe, 1988) and these saturated long chain hydrocarbons elicit synomonal and kairomonal responses in *Trichogramma* spp.

Saturated long chain hydrocarbons present on the body surface of *Spodoptera litura* (Fab.) and *Earias vitella* (Fab.) moths have been reported to elicit kairomonal response in *Trichogramma* spp. (Maruthadurai *et al*., 2011). The egg parasitoid, *T. chilonis* widely distributed in the Indian subcontinent is responsible for large-scale mortality of a variety of lepidopterans occurring in several eco-systems. It is extensively used to manage bollworm complex *viz*., *Helicoverpa armigera* (Hubner), *E. vitella*, *E. insulana* (F.), *S. litura* and *Pectinophora gossypiella* Saunders (Kumar *et al*., 2009; Fant *et al*., 2013). In order to evaluate the role of kairomones released by host insect on foraging activities by *T. chilonis* and *C. zastrowi sillemi,* laboratory bioassay were conducted with the hexane extracts (1000 ppm) of male and female whole body and larval wash of host *C. cephalonica* to demonstrate the kairomonal interaction among the parasitoid, predator and the host.

MATERIALS AND METHODS

Laboratory studies were carried out at Bio-control laboratory, Agricultural College and Research Institute, Madurai during 2014- 2015 to study the kairomonal effect of *C. cephalonica* to natural enemies.

Insect cultures

The field collected *S. litura* egg masses were maintained in containers (28 cm dia.; 25 cm height) with castor leaves for the development of larvae. From the 3rd instar onwards, larvae were reared in groups of 50 in each container with castor leaves (*Ricinus communis*). Late 4th instar was allowed to pupate in moist, loose soil. Moths (10–12 pairs) were released in mating and oviposition cages (20 x 20 x 20 cm) with 15–20% honey solution as adult food. Nerium leaves (*Nerium indicum*) were provided as an ovipositional substrate. The eggs collected from nerium leaves were used for experiment (Parthiban *et al.*, 2014; Patil *et al.*, 2015). *C. cephalonica* and egg parasitoid, *T. chilonis* was reared in the laboratory as per the protocol suggested by Navarajanpaul (1973). Mass rearing of *C. zastrowi sillemi* was carried out with *C. cephalonica* eggs as feed, adapting the method described by Swamiappan (1996).

Extraction of kairomone

The whole body washes from adult male, female and larvae of moth of *C. cephalonica* were prepared as per the method described by Ananthakrishnan *et al*. (1991). Freshly emerged, healthy, 0-24 hrs old moths of male and female were collected and kept in a deep freezer (REMI model) at –20ºC for 15 min for immobilization. Subsequently, 10 g of moths, third instar larvae and larval frass were weighed and soaked in 100 ml of distilled hexane (HPLC grade) for 24 hrs and shaked in water bath (Genuine model) at 28°C for two hours followed with 20 minutes at 50°C.These were filtered through Whatman No.1 filter paper (Yasuda 1997). The hexane fraction was subsequently concentrated by vacuum evaporation at 40° C (LARK model). The extracts were stored at –20°C in deep freezer till further use for bioassay studies. A concentration of 0.1% (1000 ppm) of the extract of host insect was prepared after dilution with hexane and used throughout the experiment.

Bioassay

Bioassay studies of whole body wash and larval exuding kairomones of host insects were carried out at 26 ± 2°C and 75 ± 5% R.H. and photoperiod 16:8 h scoto/photo regime. The procedure adopted was similar to the one described by Lewis *et al*. (1975). Clean, healthy, 0-24 hrs old eggs of *S. litura* sterilized under UV light for 45 minutes were washed twice in hexane to remove any trace of scales or kairomones present on the surface of eggs. These eggs were pasted with pure white gum on dull coloured cardboard, measuring 7 x 2 cm at the rate of average of 80 - 100 eggs per piece (egg card). Kairomone extracts (1000 ppm) of *C. cephalonica* (male moths, female moths and larvae extracts) used to treat the hexane washed eggs, separately and shade dried. Each egg card was considered as one replication and each treatment was replicated seven times. Control was maintained with hexane alone.

Egg card taken in a glass tube (7.5 x 2.5 cm) was introduced with freshly emerged *T. chilonis* adults (6:1). Per cent parasitization was observed on 3rd, 5th and 7th days after introduction. Similarly, one second instar of *C. zastrowi sillemi* was released in a vial with hexane washed *S. litura* eggs (80-100 nos.) and per cent predation was calculated 24 hr after release (Murali baskaran, 2013).

Statistical analysis

Data obtained from the bioassay of body washes of host insects were subjected to ANOVA (Analysis of Variance). Before analysis, data on per cent parasitism were transferred by arcsine transformation. In order to know the interaction between treatments, data from laboratory bioassay were subjected to factorial CRD (Completely Randomized Design) analysis and the means obtained were separated by LSD (Least Significant Difference) (Gomez and Gomez, 1984).

RESULTS

The efficacy of hexane extracts of *C. cephalonica* on parasitism corroborated that (Table 1) highest mean percentage parasitism of 44.54 by *T. chilonis* was recorded in hexane extract of female whole body wash of *C. cephalonica* (1000 ppm) followed by 35.25 percentage in male whole body wash. Among the host insect wash larval extract recorded the lowest mean percentage parasitism of 25.73, whereas the control (hexane) recorded the least mean parasitism (16.73). When the interaction between the different washes were analyzed, it was found that the female body wash of *C. cephalonica* recorded the highest mean parasitization level of *T. chilonis* on eggs of *S. litura*, recording 13.24, 49.73 and 70.66 per cent on 3rd, 5th and 7th day after introduction of parasitoids, respectively which was significantly different from hexane extract of male whole body (9.49, 37.30 and 58.95%), and larval extract (8.11, 28.46 and 40.62%) while it was 5.14, 16.72 and 28.34 per cent parasitization in hexane alone treated eggs for the same period.

Similarly, highest mean per cent emergence (67.84%) was recorded in female body wash of *C. cephalonica* followed by male body wash (56.33%) (Table 2). The lowest mean emergence was recorded in larval extract (39.47%) and the lowest mean per cent emergence was recorded in control (28.94%).

Predatory activity by *C. zastrowi sillemi* was enhanced from 29.43 (hexane treated eggs of *S. litura*) to 69.14 per cent (Table

Table 1: Per cent parasitism by *Trichogramma chilonis* on eggs of *Spodoptera litura*, as influenced by hexane extracts of *Corcyra cephalonica*

Insect samples	% parasitization by *T. chilonis* after*			Mean
	3rd day	5th day	7th day	
Male whole body	9.49(17.94)b	37.30(37.64)b	58.95(50.16)b	35.25(36.42)b
Female whole body	13.24(21.34)a	49.73(44.85)a	70.66(57.21)a	44.54(41.87)a
Larval extract	8.11(16.54)c	28.46(32.24)c	40.62(39.59)c	25.73(30.48)c
Control (Hexane)	5.14(13.10)d	16.72(24.14)d	28.34(32.17)e	16.73(24.14)d
SEd	0.4351	0.2680	0.2560	0.2714
CD (P=0.05)	1.0034	0.6180	0.5902	0.6257

*Mean of seven replications; Figures in parentheses are arcsine transformed values; In a column, means followed by the same letter(s) are not significantly different by LSD (P=0.05)

Table 2: Per cent emergence of *T. chilonis* on eggs of *S. litura*, as influenced by hexane extracts of *C. cephalonica*

Insect samples	% emergence of *T. chilonis**
Male whole body	56.33(48.64)[b]
Female whole body	67.84(55.45)[a]
Larval extract	39.47(38.92)[c]
Control (Hexane)	28.94(32.55)[d]
Mean	48.14(43.93)
SEd	0.2536
CD (P=0.05)	0.5848

*Mean of seven replications; Figures in parentheses are arcsine transformed values; In a column, means followed by the same letter(s) are not significantly different by LSD (P=0.05)

Table 3: Per cent predation by *Chrysoperla zastrowi sillemi* on eggs of *S. litura*, as influenced by hexane extracts of *C. cephalonica*

Insect samples	% predation by *C. zastrowi sillemi* after 24 h*
Male whole body	57.25(49.17)[b]
Female whole body	69.14(56.26)[a]
Larval extract	41.51(40.11)[c]
Control (Hexane)	29.43(32.85)[e]
Mean	49.33(44.61)
SEd	0.2538
CD (P=0.05)	0.5853

*Mean of seven replications; Figures in parentheses are arcsine transformed values; In a column, means followed by the same letter(s) are not significantly different by LSD (P=0.05)

3), 24 hr after treatment when treated with hexane extract of female whole body, followed by hexane extract of male whole body (57.25%) and larval extract (41.51%).

DISCUSSION

The outcomes of the present study indicate that kairomonal compounds from *C. cephalonica* female whole body wash increased parasitization when applied over target sites. This findings is in agreement with the earlier reports in this direction in a number of host-parasitoid systems (Shu *et al.*, 1990). This supports the present findings where the whole body washes of female *H. armigera* and *C. cephalonica* moths recorded the highest PAI, parasitism and emergence by *T. chilonis* (Anathakrishnan *et al.*, 1991). The present result was endorsed with the findings of Singh *et al.* (2002) who stated that an analysis of *H. armigera* whole body wash for possible kairomonal substances using gas chromatography indicated the presence of fifteen saturated hydrocarbons were identified among which heneicosane and hexacosane were the major ones. Rest of the saturated hydrocarbons found were heptadecane, nonadecane, hexadecane and pentadecane and tricosane this hydrocarbons may be reason for enhanced parasitism, emergence and predation. The significance of these kairomonal substances in behavioural manipulation of entomophagous insects was earlier emphasized and reviewed by Lewis *et al.* (1976).

Paul *et al.* (2002) explicated that pentacosane and hexacosane recorded very high parasitoid activity index and parasitism for *T. brasiliensis* and *T. exiguum* indicating high kairomonal activity. Srivastava *et al.* (2008) found that kairomones from male *S. litura* and female *S. exigua* showed the highest parasitoid activity index (PAI) and parasitism by *T. chilonis*. The whole body washes of *C. cephalonica* female showed higher parasitism by *T. brasiliensis* and *T. japonicum* as compared to that of male moth (Paul *et al.*, 1997).

Attraction of *T. chilonis* was more towards female body wash of *Chilo partellus* (Swinhoe), *Sesamia inferens* Walker and *Sitotroga cerealella* Oliver as compared to male body wash (Padmavathi and Paul, 1997). Srivastava *et al.* (2008) recorded more number of favourable hydrocarbons in *S. litura* male and *S. exigua* female and this is in agreement with present findings. Paramasivan *et al.* (2004) identified more number of favourable hydrocarbons in female body wash of *C. partellus* as compared to male.

The whole insect body of *E. vittella* was found to increase parasitoid activity index (PAI) and per cent parasitism by *Trichogramma* spp. which may be attributed to the presence of various saturated hydrocarbons in the range of C_{13} to C_{30} with varying quantities (Maruthadurai *et al.*, 2011; Mahesh *et al.*, 2012). Presence of single chain hydrocarbons like dotriacontane and nonadecane would have been responsible for the enhanced predatory activity of *C. carnea*, as suggested by Singh and Paul (2002). Bakthavatsalam and Singh (1999) exemplified scales and abdominal tip extracts of *C. cephalonica* and *H. armigera* elicited good behavioural response in *C. zastrowi sillemi* larvae. Hegde *et al.* (2000) noticed the grub of *C. zastrowi sillemi* to spend the longest time (0.98 min.) near wax droplets smeared with *H. armigera* scale extract, followed by *H. armigera* egg extract (0.54 min.) and abdominal tip extract (0.34 min.).

Laboratory observations on parasitism rates by *T. chilonis* in response to *H. armigera* female whole body wash, treatments reveal the importance of kairomones from female moths. Similar observations have been made by Nordlund *et al.* (1976) on *T. pretiosum* Riley support our study on the role of kairomones in improving parasitism. Larvae of the generalist predator *C. zastrowi sillemi* have specific preference to certain hydrocarbons and other chemicals at a particular concentration. Such preferential behaviour of the larvae may be utilized for their activity of manipulation in the release programmes to enhance their host searching activity.

Biological control of insect pest has become increasingly important in agriculture because of the need to minimize the amount of toxic chemicals released into the environment. The present study indicates that kairomone compounds from *C. cephalonica* female whole body wash in the manipulation of parasitoid activity could play a major role in future biological control programmes, since large cultures of moths are available in parasitoid breeding laboratories for efficient extraction and use of kairomones.

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