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Impact of hyperparasitism on the dynamics of *Apanteles* sp. (Hymenoptera: Braconidae) against rice skipper, *Parnara guttata* Bremer and Grey in Anantnag, Kashmir

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ABSTRACT: *Trichomalopsis apanteloctena* (Crawford) was found to be commonly associated with *Apanteles* sp. on *Parnara guttata* on paddy, causing its hyperparasitism from third week of August till October, during 2003-2005, in Kashmir valley. Three years' data indicated a total mean of 8.8 individuals of *T. apanteloctena* developing per cocoon cluster of *Apanteles* sp. that averaged 30.2. Per cent hyper parasitism and per cent cocoon cluster hyperparasitism were 20.1 and 44.51, respectively, and each of these parameters had a positive correlation with mean number of hyperparasitoids per cocoon cluster. The mean number of *Apanteles* sp. per cocoon cluster was, however, found to be negatively correlated with cocoon cluster hyperparasitism (r = -0.42*; d. f. = 19) and mean number of hyperparasitoids/ cocoon cluster (r = -0.44*; d. f. = 19). Since the hyper parasitoids appeared late during third week of August each year, overall impact on the activity of *Apanteles* sp. was, therefore, insignificant except during October, which led to a noticeable decline both in mean number of *Apanteles* cocoon cluster^{-1} and per cent host larval parasitism.

KEY WORDS: *Apanteles* sp., hyperparasitism, Kashmir, paddy, *Parnara guttata, Trichomalopsis apanteloctena.*

INTRODUCTION

Hyperparasitism is a condition where secondary parasitoids such as braconids, chalcids and ichneumonids develop inside a primary parasitoid and cause natural suppression of the latter. On the one hand where primary parasitoids are useful and play a significant role in the natural suppression of a variety of insect pests, either by their indigenous presence or through augmentative releases, the role of hyper parasitoids on the other hand is always antagonistic to primary parasitoids and thus counterproductive. The aspect of hyperparasitism is mostly ignored, probably due to its negligible or moderate impact on primary parasitoids, however, there are instances where it caused serious concern in many biological control programmes (Rosen and Debach, 1973; Delucchi *et al*., 1976; Rosen, 1986).

Trichomalopsis apanteloctena (Crawford) is a common pteromalid hyperparasitoid of *Apanteles baoris, A. ruficrus, Cotesia parnarae*, *Rhysipolis parnarae*, etc. attacking *Parnara* spp. and *Cnaphalocrocis medinalis* on rice, and many other lepidopteran pests in different parts of Asia (Ahmad and Zaki, 2008; Basit and Saikia, 2006; Kamijo and Grissell, 1982; Matsumura, 1992; Sathe and Bhoje, 2000). It is reported to influence the activity of some of the above mentioned braconids, as documented by Belokobyl and Kon (1988), Zhang (1986) and Rao and Behera (1986). Ahmad and Zaki (2004) recorded *T. apanteloctena* from *Apanteles* sp. for the first time from Kashmir.

Apanteles sp. constitutes one of the predominant species among known larval and pupal parasitoids of the rice skipper, *Parnara guttata* Bremer and Grey in the valley, which include one unidentified species each of Ichneumonidae and Tachinidae and a *Brachymeria* sp. It causes an average of 27.4 per cent parasitism of the larvae as compared to 3.45, 9.75 and 10.28 per cent by the above mentioned parasitoids, respectively (Ahmad and Zaki, 2008) during 2003-2004. Comparatively increased level of parasitism by *Apanteles* sp. is because of its gregarious endoparasitic nature achieved through its inherent property of depositing multiple number of eggs in the host larvae, *i.e.*, 3rd instar. The larvae of the parasitoid after hatching and attaining maturity inside the host emerge outside by puncturing the host body and pupate individually in whitish and elongated silken cocoons, all weaved together in a batch of one or two, referred to as cocoon cluster, placed close to the host larva, and from each cluster a number of adults emerge. The number of individuals of *Apanteles* sp. per cocoon cluster, however, becomes affected when it is hyperparasitised by *T. apanteloctena*, which is commonly associated with *Apanteles* sp. in Kashmir valley. *T. apanteloctena* is a solitary ectoparasitoid of *Apanteles* spp. whose females lay eggs on the surface of the newly formed cocoon cluster of the latter. The larvae of *T. apanteloctena* after hatching obtain nutrition externally from the developing pupae of *Apanteles* inside cocoons, causing death to the latter, and pupate close by, in the parchment of host cocoon cluster, as reported by Rao and Behera (1986). In our present investigation no other larval and pupal parasitoids of *P. guttata* displayed hyperparasitism.

Although *P. guttata* is a minor pest of paddy in Kashmir valley, it is of common occurrence during July-October, infesting transplanted rice plants from early to late stage of the crop. Although the impact of damage by the pest is unknown from the valley so far, Pang (1987) reported yield loss/ 100 tillers from 3.3 to 31.8 per cent in China, whereas Jana *et al*. (1994) reported little or insignificant yield loss in West Bengal.

In view of the tremendous bioregulatory potential of *Apanteles* sp. against *P. guttata*, the present study was conducted to investigate the level of hyperparasitism in *Apanteles* and its impact on its population dynamics, if any.

MATERIALS AND METHODS

The present study was conducted at Regional Rice Research Station, Khudwani (1560 a.s.l., 72°N, 32°E), Anantnag of Sher-e-Kashmir University of Agricultural Sciences & Technology (Kashmir) during *Kharif* 2003 to 2005, in paddy fields with a total area of approximately 10 hectares, without use of any insecticides ever. Weekly collections of late 3rd to final instar larvae of *P. guttata*, including parasitized (as obvious from the presence of whitish cocoon clusters placed close to the host body), unparasitised or those showing no symptom of parasitisation at the time of collection, were made from a total area of about three hectares, during *Kharif* 2003-2005. Each year, a different paddy field (one hectare) consisting of ten blocks was surveyed from first week of July till October. All the ten blocks were thoroughly observed every week for the collection of host larvae. Individual larva with or without cocoon cluster was kept in a test tube (15 x 2.5cm) plugged with cotton and kept in thermostat BOD, maintained at 27 ± 1°C and 65 ± 5 per cent RH. The larvae without any early symptom of parasitism, like sluggishness and yellowing of body, were supplied fresh leaves daily until the appearance of cocoon cluster of *Apanteles* or formation of host pupa. The samples were observed daily for the appearance of cocoon cluster, emergence of *Apanteles* and *T. apanteloctena*. Samples showing emergence of parasitoids were kept for two more days in thermostat for their complete emergence, which were then killed by ethyl acetate and identified under stereoscopic binocular microscope.

The following parameters were recorded on weekly basis, from July to October, during 2003-2005. Two weeks' observations were later clubbed as presented in Table 1, for the purpose of subsequent analysis of data. A = No. of collected host larvae; B = No. of parasitized host larvae; Rate of larval parasitism (%) = B / A x 100; C = No. of collected cocoon clusters; D = No. of cocoon clusters that yielded hyper parasitoids; Rate of cluster hyperparasitism (%) = D / C x 100; E = Mean number of *Apanteles* emerged cocoon^{-1} cluster of *Apanteles*; F = Mean number of hyperparasitoids emerged cocoon^{-1} cluster of *Apanteles*; Rate of hyperparasitism (%) = ∑F / ∑E + ∑F x 100.

Three years' data on mean number of *Apanteles* and *T. apanteloctena* cluster^{-1}, per cent host larval parasitism, per cent cluster hyperparasitism and per cent hyperparasitism of *Apanteles* (Table 2) were based on five replications, of two weeks, collected from ten blocks. Minitab was used to analyze data for two-way ANOVA. Per cent parasitism by *Apanteles* was determined on the basis of total number of larvae collected / week. This method has also been discussed by Ahmad and Zaki (2008).

RESULTS AND DISCUSSION

Infestation of paddy by larvae of *P. guttata* was noticed during the first week of July till late October, with maximum incidence during first and second weeks of September, followed by a decline thereafter. Larval parasitism of *P. guttata* by *Apanteles* sp. was observed from third week of July till late October with peak parasitism during third and fourth weeks of September each year. Per cent larval parasitism was found to be positively correlated with the mean number of *Apanteles*/cocoon cluster (r = 0.57**; d. f. = 22). The latter displayed a gradual increase from July to later half of September, followed by a decline thereafter (Table 1). Three years' data on per cent host larval parasitism and mean number of *Apanteles*/cocoon cluster when analyzed separately through two-way ANOVA indicated significant differences only period wise, *i.e.*, July – October, but were insignificant for year and also interaction between year and period , for both the parameters (Table 2).

Hyperparasitism of cocoon cluster of *Apanteles* by *T. apanteloctena* was first observed from third week of

Table 1. Dynamics of *Apanteles* sp. and its hyperparasitoid, *Trichomalopsis panteloctena* on *Parnara guttata* on rice during 2003-2005

Year/ Period	Parameters*	July 1st & 2nd week	July 3rd & 4th week	Aug 1st & 2nd week	Aug 3rd & 4th week	Sept 1st & 2nd week	Sept 3rd & 4th week	Oct 1st & 2nd week	Oct 3rd & 4th week
2003	A	20	29	61	110	163	84	52	39
	B	0.0	2.0	5.0	19.0	57.0	42.0	20.0	12.0
	B/A	0.0	6.9	8.2	17.3	34.9	50.0	38.4	30.8
	C	0.0	2.0	7.0	21.0	65.0	47.0	23.0	17.0
	D	0.0	0.0	0.0	2.0	17.0	21.0	16.0	13.0
	D/C	0.0	0.0	0.0	9.5	26.1	44.7	69.6	76.5
	E	0.0	31.5	35.4	36.3	44.1	47.5	24.3	15.2
	F	0.0	0.0	0.0	2.4	3.7	6.7	9.5	12.7
	∑F / ∑E + ∑F =	0.0	0.0	0.0	6.3	7.8	12.4	28.2	43.9
2004	A	16	52	70	129	154	97	48	31
	B	0.0	2	7	25	59	51	18	11
	(B/A)	0.0	3.8	10.0	19.4	38.3	52.6	37.5	35.5
	C	0	2	7	34	69	60	21	11
	D	0.0	0.0	0.0	3	20	22	12	9
	(D/C)	0.0	0.0	0.0	8.8	28.9	36.6	57.1	81.8
	E	0.0	26.5	27.0	27.1	35.5	43.7	30.5	18.0
	F	0.0	0.0	0.0	1.1	3.2	5.9	10.4	12.9
	∑F / ∑E + ∑F =	0.0	0.0	0.0	3.9	8.3	11.9	25.4	41.7
2005	A	23	62	80	130	140	99	71	51
	B	0.0	4	8	24	45	46	23	13
	(B/A)	0.0	6.4	10.0	18.5	32.1	46.5	32.4	25.5
	C	0.0	4.0	10.0	27	49	54	30	18
	D	0.0	0.0	0.0	3	15	22	19	15
	(D/C)	0.0	0.0	0.0	11.1	30.6	40.7	63.3	83.3
	E	0.0	27.2	28.4	28.9	33.0	37.4	18.5	11.2
	F	0.0	0.0	0.0	1.3	2.6	5.9	10.2	12.5
	∑F / ∑E + ∑F =	0.0	0.0	0.0	4.3	7.3	13.6	35.5	52.7

* The alphabets used have been elaborated in materials and methods

August and continued till October each year. Per cent hyperparasitism of cocoon cluster of *Apanteles* sp. as well as rate of hyperparasitism indicated a gradual rise, being the maximum during third and fourth weeks of October (Table 1). Further, these two parameters, separately, displayed a positive correlation both with host larval parasitism (r = 0.72**; d. f. = 22 and r = 0.53*; d. f. = 22), as well as mean number of hyperparasitoids cocoon^{-1} cluster (r = 0.97**; d. f. = 13 and r = 0.95**; d. f. = 13), respectively. However, mean number of *Apanteles* cocoon^{-1} cluster was found to be negatively correlated both with cocoon cluster hyperparasitism (r = -0.42*; d. f. = 19) and mean number of hyperparasitoids cocoon^{-1} cluster of *Apanteles* (r = -0.44*; d. f. = 19), respectively.

Increased level of host larval parasitism by *Apanteles* sp. was because of its predominance over other parasitoids of *P. guttata* in paddy ecosystem, achieved through its inherent property of superparasitism, *i.e.*, development of multiple number of offspring per host larva. Delayed but simultaneous occurrence of the hyperparasitoid, *T. apanteloctena* in the cocoon cluster of *Apanteles* sp., however, affected the host larval parasitism to some extent, by hyperparasitizing the number of viable cocoons of *Apanteles* sp., as also indicated by their negative correlation. But, as *T. apanteloctena* appeared during third week of August, this enabled *Apanteles* sp. to flourish unrestrained, causing thereby sufficient level of host larval parasitism till the last week of September. However, the hyperparasitoids gained numerical

Table 2. Three years' pooled means of number of *Apanteles* and *Trichomalopsis apanteloctena* per cluster, per cent host larval parasitism, per cent cluster hyperparasitism and per cent hyperparasitism of *Apanteles*; and two-way analysis of variance during 2003-2005

No. of *Apanteles*/ cluster	No. of *T. apanteloctena*/ cluster of *Apanteles* sp.	Per cent host larval parasitism	Per cent cluster hyper parasitism	Per cent hyper / parasitism
Mean (SD, n)	Mean (SD, n)	Mean (SD, n)	Mean (SD, n)	Mean (SD, n)
30.2 (21.7, 300)	7.55 (8.8, 240)	26.41 (16.5, 105)	44.51 (28.5, 75)	20.1 (19.7, 75)
Two-way ANOVA with main effects				
F (d.f.) P Year 1.5 (2) ns period 22.13 (4) 0.000 Year * period 0.52 (8) ns	F (d.f.) P 0.35 (2) ns 17.84 (4) 0.00 0.1 (8) ns	F (d.f.) P 0.69 (2) ns 49.92 (6) 0.00 0.51 (12) ns	F (d.f.) P 0.43 (2) ns 56. 7 (4) 0.00 0.26 (8) ns	F (d.f.) P 0.24 (2) ns 29.19 (4) 0.00 0.26 (8) ns

SD = Standard deviation; n = Total number of observations; ns = non-significant; d. f. = degree of freedom

density per cocoon cluster of *Apanteles* sp. Gradually, both through increased cluster hyperparasitism as well as rate of hyperparasitism, countered the activity of *Apanteles* sp. resulting into observed decline in mean number of the latter per cocoon cluster. Low level of hyperparasitism until September is related to slow rate of hyperparasitism by *T. apanteloctena* which was further marginalized by over production of *Apanteles* sp. due to host larval abundance for parasitism. Decline in host larvae for parasitism after September, because of advanced stage of crop, the number of cocoon clusters of *Apanteles* sp. being therefore reduced per unit area, increased the rate of hyperparasitism through comparatively increased number of *T. apanteloctena*, that ultimately reduced the overall mean number of *Apanteles* sp. per cocoon cluster (Table 1). Although negative correlation between the two communities, *i.e.*, *Apanteles* sp. and *T. apanteloctena*, provides testimony of the antagonistic role of the latter in the given ecosystem, nevertheless, present level of hyperparasitism (overall 20.1 per cent) was found unable to suppress the total mean number of *Apanteles* sp./ cocoon cluster below 30.2 (Table 2). Further, as the hyperparasitism prevailed more during advanced stage of the crop which hardly invited fresh larval incidence of *P. guttata*, total impact of hyperparasitism on the dynamics of *Apanteles* sp. is considered of little significance. As against earlier observation (Zhang, 1986), which recorded the rate of hyperparasitism as high as 41.0 to 96.5 per cent in *Apanteles ruficrus* on *Mythimna separata* in rice, the present level of hyperparasitism (20.1 per cent) alludes to merely a natural coexistence between the two communities of *Apanteles* sp. and *T. apanteloctena* involving insignificant negative effect on the former. Substantial reduction in the number of *Apanteles* sp. during third and fourth weeks of October nevertheless might have caused reduction in the number of hibernating *Apanteles* sp. in host larva, which probably resulted in their late appearance, *i.e.*, during third week of July, exhibiting poor percentage of host larval parasitism during this period.

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