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Research Article

Optimum density of *Eocanthecona furcellata* (Wolff) (Hemiptera: Heteroptera: Pentatomidae) to be considered for mass production under laboratory conditions

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ABSTRACT: *Eocanthecona furcellata* (Wolff) is a potential native predator of lepidopteran larvae that can be easily reared under laboratory conditions and released in augmentative biocontrol for management of pests in various crops. For successful mass production of any predator cannibalism under crowded rearing conditions is the major limiting factor. In the present study, attempts were made to know the ideal population considered for group rearing with minimal or no cannibalism. It was recorded that the predator population of 5 to 25 on *Corcyra cephalonica* (S.) and *Galleria mellonella* L. and 5 to 30 on *Samia cynthia ricini* Boisd. and *Spodoptera litura* F. was feasible for group rearing with higher percent survival rate when reared in different group arenas. The survival percent was higher on hosts, *C. cephalonica*, *G. mellonella*, *S. litura* and recorded lower on *S. cynthia ricini* under group rearing condition.

KEY WORDS: *Corcyra cephalonica*, *Eocanthecona furcellata, Galleria mellonella*, group rearing, optimum density, *Samia cynthia ricini, Spodoptera litura*

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INTRODUCTION

Eocanthecona furcellata (Wolff) (Hemiptera:Heteroptera: Pentatomidae:Asopinae) is a predatory Asopine bug and considered as one of the promising predators of many lepidopteran pests of economically important crops. It is distributed world-wide, especially Southeast Asian countries like India, Japan, Taiwan, the southern part of China and Okinawa (Prasad *et al*., 1983; De Clercq, 2000; Yasuda, 2000). It was found associated with *Spodoptera litura* F. and *Chrysodeixis acuta* Walker) of soybean (Ahirwar *et al*., 2015), crops like paddy (Sharma *et al*., 2015), red gram, chickpea, groundnut, urd bean, mung bean, cotton and vegetable fields preying on larvae of *Helicoverpa armigera* Hubner, tobacco caterpillar and hairy caterpillars (Yi and Kyi, 2000; Nyunt, 2001; Nabapure and Agnihotri, 2011), okra lepidopteran pests like *Earias insulana* (Fabricius) and *Earias vitella* (Fabricius) (Bhatt *et al*., 2018), American bollworm in Myanmar (Yi and Kyi, 2000; Aruna and Devi, 2015) and in forest ecosystems (Aland *et al*., 2010). The mass rearing of *E. furcellata* is feasible and cost effective on easily available and maintained hosts like *C. cephalonica*, *G. mellonella, S. cynthia ricini* and *S. litura* but for successful mass production of the predator, feasibility of group rearing is important. It is necessary to know the ideal population to be considered for group rearing. Hence, the present study was conducted to know the survival rates of *E. furcellata* at different group arenas on easily available lepidopteran prey *viz*., *C. cephalonica*, *G. mellonella*, *S. cynthia ricinia* and *S. litura*, respectively.

MATERIAL AND METHODS

Rearing of *Corcyra cephalonica* (Stainton)

The *C. cephalonica* was maintained in the laboratory on broken sorghum grains at ICAR-NBAIR, Bengaluru. The eggs of *C. cephalonica* (1cc/kg of feed) was added as inoculating material to broken sorghum grains and were maintained at 28°C, 65% relative humidity. The food was supplemented with streptomycin sulphate and yeast tablets, 0.5 mg/kg of food material (250 g sorghum grains + 0.1 g streptomycin + 2 g yeast) (Chandrika and Sathiamma, 2007; Wadaskar *et al*., 2015).

Rearing of *Galleria mellonella* (L.)

The mass rearing of *G. mellonella* early instars (first, second and third) was done initially on pieces of honey comb and later instars were transferred to the artificial diet (Metwally *et al*., 2012; Mohamed and Coppel, 2017). Pupae were placed in containers provided with mesh (20 × 20 cm) and after emergence of adults, folded strips of paper, with slits were placed as oviposition substrate for female moths to lay eggs. Honey-water mixture (1:1) was provided along with vitamin E drops as source of adult nutrition. The collected egg masses were spread on honey comb or 2 cm thick layer of artificial diet and placed in an incubator at 30°C.

Rearing of *Samia cynthia ricini* Boisd.

Samia cynthia ricini is the domesticated silkworm and adopted for indoor rearing around the year. The larval rearing technique followed in the present study was surface (tray) rearing technique (Meth and Gogoi, 2016). Castor leaves were provided as food on daily basis. Matured larvae which turns to light orange colour were picked up and transferred on to petioles of castor leaves for pupation. About 15-35 cocoons along with the petiole of castor leaves were kept in cage (60x45x35cm) for emergence of the moths. Moths that emerged were allowed freely to mate randomly with males and provided with 50% honey solution and vitamin E soaked cotton for nourishment and to increase the fecundity, respectively.

Rearing of *Spodoptera litura* (Fabricius)

The stock culture of *S. litura* was obtained from the laboratory of ICAR-NBAIR and from castor plots of ZARS, UAS, GKVK, Bengaluru. The culture was maintained at 28 ± 2°C, 60 % RH on artificial diet as suggested by Shorey and Hale (1965) and Wakamura (1988). Egg masses collected were surface-sterilized with 0.01% sodium hypochlorite (Gupta *et al*., 2013). The larvae were group reared initially by providing them with castor leaves in a plastic container with blotting paper at the bottom. The newly emerged moths of *S. litura* were placed in well ventilated plastic containers of 20×15cm size. Adult moths were provided with the 50% honey solution and water on two cotton swabs, which were placed in Petri plates. The inner wall of the container was lined with paper to obtain egg masses. Freshly laid egg masses were surface sterilized by dipping in 10% formalin to avoid microbial contamination.

Rearing of predator *E. furcellata*

Initial culture was built up through the field collected eggs and adults of *E. furcellata* obtained from apple fields of Chinthapalli, Visakhapatnam, Andhra Pradesh (82.35ºN and 17.87ºE). The adult bugs of *E. furcellata* were kept in containers (25×25cm) covered inside by blotting paper and covered with black cotton cloth for aeration. Bugs were provided with lepidopteran prey, *C. cephalonica* or *G. mellonella* along with castor leaves for extra nutrient benefits on daily basis. Newly emerged adults were paired and females were transferred to the oviposition cages. Eggs laid by females of *E. furcellata* on the castor leaves or blotting paper were kept separately in the breeding dishes with sieve cap for hatching. The moistened cotton wool soaked in water is given for the I instar nymphs for survival and for the II instar nymph's lepidopteran larvae as prey. Nymphs from III instar onwards were kept in groups of 25-30 in breeding dishes (7x5 cm) with prey larvae to avoid high rates of cannibalism.

Experimental procedure

For mass production, one important factor considered was feasibility of group rearing. To know the optimum population for group rearing, each treatment group *i.e*., 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 numbers of newly hatched nymphs of *E. furcellata* were placed in each of the three replicate arenas. Each container was supplemented with a tender leaf of castor to get extra nutrient requirement and base of petiole was wrapped in wet cotton to maintain humid conditions. Each treatment group was given with ample prey of *C. cephalonica*, *G. mellonella, S. cynthia ricini* and *S. litura*.

Statistical analysis

The statistical analysis of means and standard errors were carried out by software SPSS (Khuhro *et al*., 2012). Mean of the per cent values were transformed using square root transformation ($\sqrt{X + 0.5}$) and subjected to ANOVA. Further, Tukey's post hoc test was carried out for means of the treatments to see if any significant differences occurred between the different treatments. The SPSS software was used for performing ANOVA and Post hoc tests.

RESULTS AND DISCUSSION

In the present study, the survival rate was recorded by rearing of *E. furcellata* by categorizing into various batches of 1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 numbers, on hosts *viz*., *C. cephalonica* (Figure 1), *G. mellonella* (Figure 2), *S. cynthia ricini,* (Figure 3) and *S. litura,* respectively. Tukey HSD means for homogenous subsets shows that there was no significant difference between batches (5, 10, 15, 20, 25) when reared on *C. cephalonica* and *G. mellonella* and between groups (5, 10, 15, 20, 25, 30) on *S. cynthia ricini,* and *S. litura*. The survival percent was high on hosts, *C. cephalonica*, *G. mellonella*, *S. litura* and recorded low on *S. cynthia ricini* (Table 1). On all the hosts, individual rearing was not feasible because the survival rate was very low when compared with that of rearing in batches. Mortality was not due to cannibalism, it might be due to communal feeding behaviour of the predator, *E. furcellata.*

Table 1. Comparison of survival of *E. furcellata* when reared in different density on various lepidopteran prey

Density of *E. furcellata*	Survival rate of *E. furcellata* on various prey			
	C. cephalonica	*G. mellonella*	*S. cynthia ricini*	*S. litura*
5	33.33	33.33	33.33	33.33
10	86.66	93.33	80	93.33
15	90	90	80	90
20	88.88	84.44	75.55	84.44
25	88.33	80	80	80
30	74.44	73.33	81.33	74.44
35	60	64.76	63.80	64.76
40	65.83	65.83	68.33	70.83
45	57.77	60.74	62.96	73.33
50	46	53.33	57.33	61.33
P value	0.009	0.016	0.034	0.0205
F	2.817	3.307	2.984	2.519

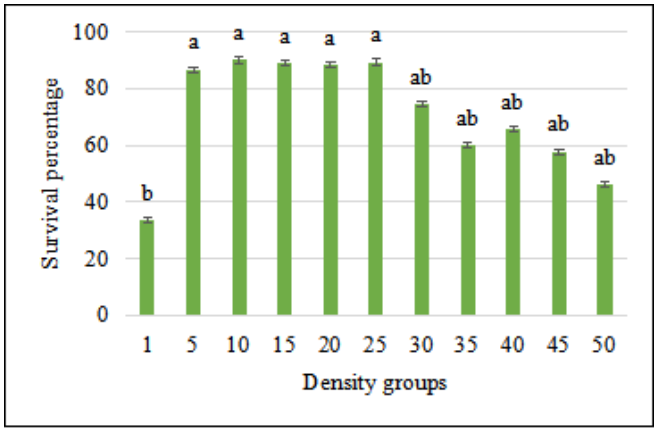

Fig. 1. Survival rate of *E. furcellata* at different density groups reared on host, *C. cephalonica*. Different letters indicate the significant differences of homogenous means using Tukey HSD.

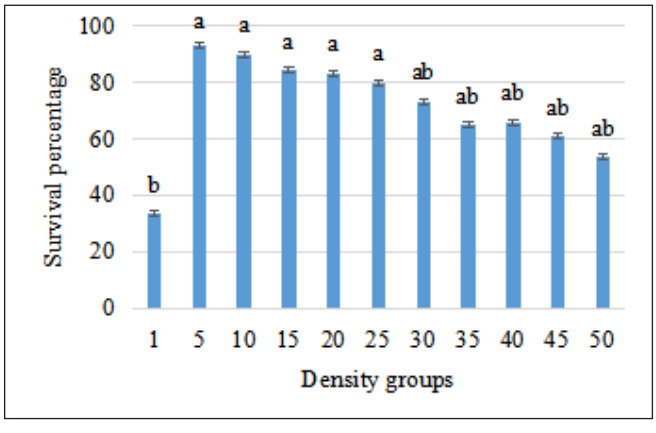

Fig. 2. Survival rate of *E. furcellata* at different density groups reared on host, *G. mellonella*. Different letters indicate the significant differences of homogenous means using Tukey HSD.

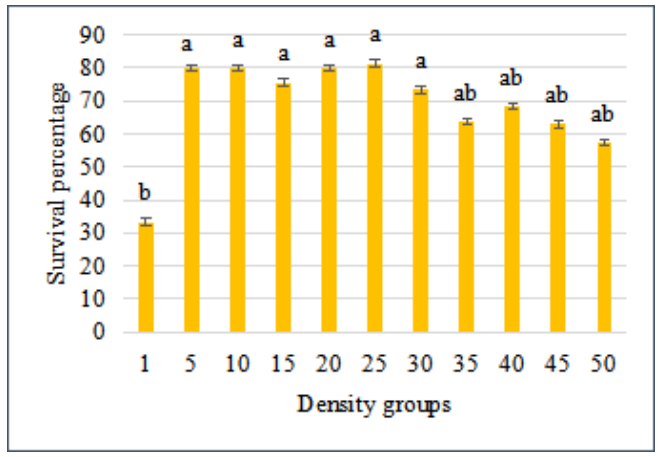

Fig. 3. Survival rate of *E. furcellata* at different density groups reared on host, *S. cynthia ricini.* Different letters indicate the significant differences of homogenous means using Tukey HSD**.**

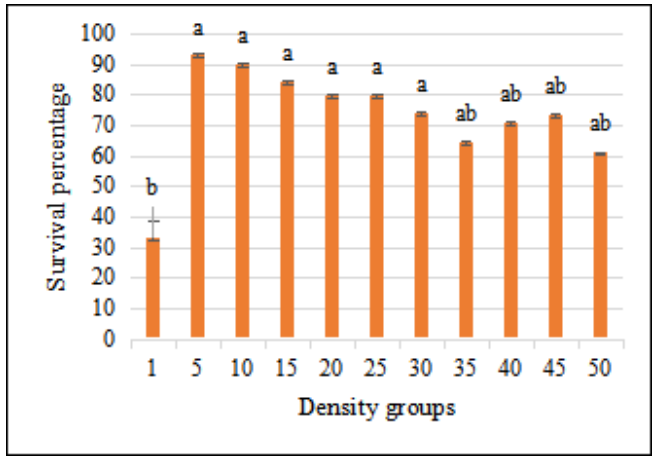

Fig. 4. Survival rate of *E. furcellata* at different density groups reared on host, *S. litura.* Different letters indicate the significant differences of homogenous means using Tukey HSD.

Eocanthecona furcellata is considered as hostile predator and fed communally (Plate 1). Cannibalism was observed usually in III, IV, V and adults of both sexes, infrequently during the II instars. In previous study, cannibalism was observed among all nymphal instars except in I and II instars (Usha Rani and Vukkala, 1993). Cannibalism was often observed and in higher rate among the freshly moulted V instar to adult stage attacking at the soft ventral parts of the abdomen. After initial attack, other predators joined and fed communally, until the prey was completely consumed. Similarly, Usha Rani and Vukkala (1993) reported that soft parts and freshly moulted parts are more prone to cannibalism and also communal feeding behaviour.

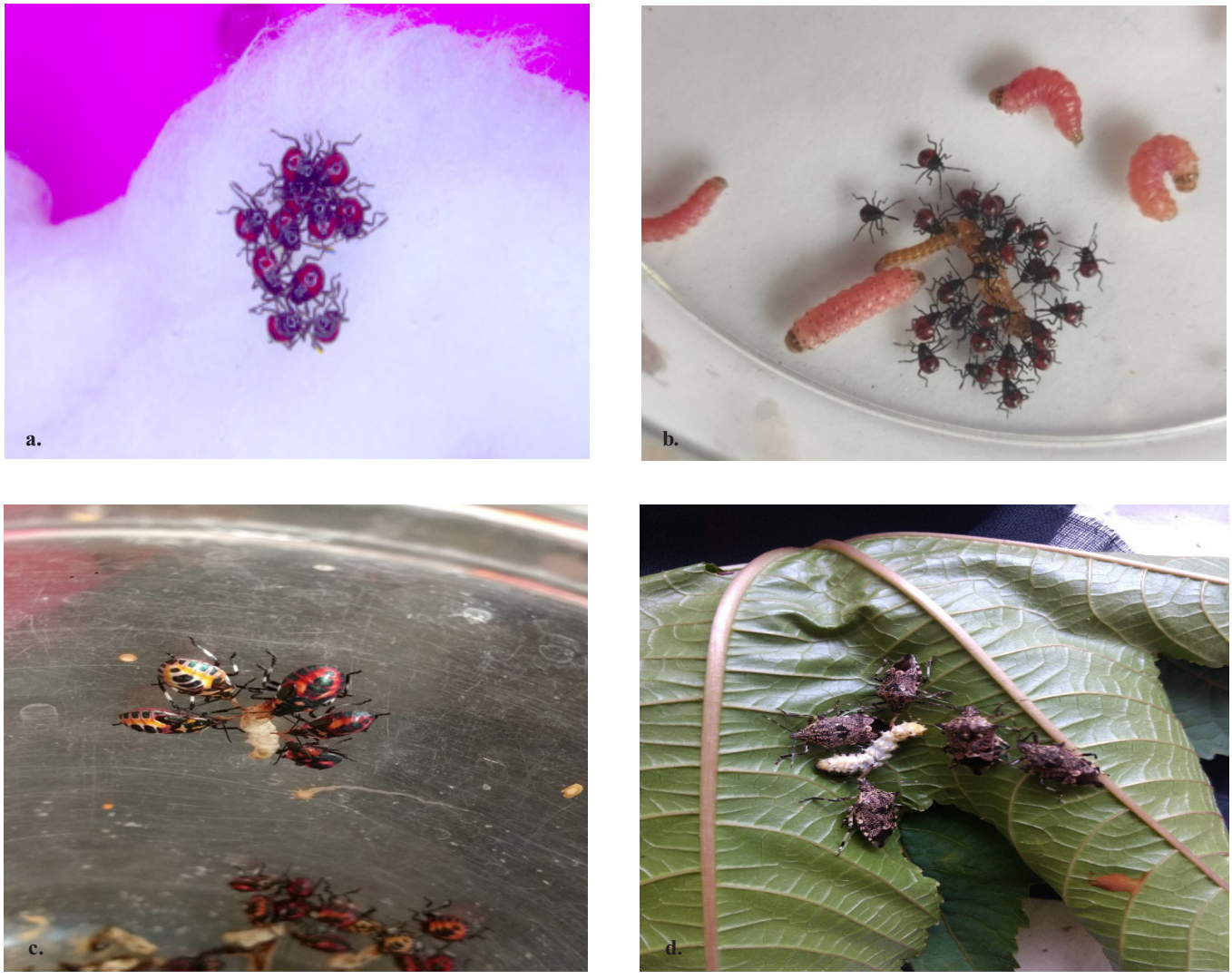

Plate 1. Communal feeding behaviour of *Eocanthecona furcellata* a. 1st instar nymphs feeding on moist cotton b. 2nd instar nymphs feeding on *Leucinodes orbonalis* c. 5th instar nymphs feeding on *G. mellonella.* d. Adults feeding on *S. cynthia ricini.*

Cherian and Brahmacheri (1941) reported that when fresh green twigs and caterpillars were offered in rearing jars at the same time, all instars of *E. furcellata,* except the 1st instar fed on plant sap (not predatory in nature) and only later instars (2nd to 5th) turned their attention to the caterpillars. In the present study, the survival per cent recorded was high on various hosts, *C. cephalonica*, *G. mellonella*, *S. litura* and recorded low on *S. cynthia ricini* under group rearing condition. Tukey HSD means for homogenous subsets shows that there was no significant difference of survival rate between group rearing (5, 10, 15, 20, 25) on *C. cephalonica* and *G. mellonella* and between groups (5, 10, 15, 20, 25, 30) on *S. cynthia ricini*. The ideal population for group rearing was 5 to 25 on *C. cephalonica* and *G. mellonella* and 5 to 30 on *S. cynthia ricini* and *S. litura.*

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