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Predatory potential of *Platynectes* sp. (Coleoptera: Dytiscidae) on *Aedes albopictus*, the vector of dengue/chikungunya in Kerala, India

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Abstract. Unused and discarded latex collection containers (LCCs) are the major breeding habitats of *Aedes albopictus* in the rubber plantations of Kerala, India. *Platynectes* sp. (Family: Dytiscidae) was observed to invade these habitats during the monsoon season and voraciously devour the larval instars of this major vector species of arbo-viral diseases. Field observations showed a reduction of 70.91% (p = 0.0017) and 100% in *Aedes* larval density, on the first and four days post release of eight beetles per LCC respectively. In laboratory, a beetle was found to devour 17.75 + 5.0 late larval instars of *Ae. albopictus* per day. Our findings indicate *Platynectes* sp. could be a potential bio-control agent against *Ae. albopictus*, the vector of chikungunya/dengue fevers, in rubber plantations.

INTRODUCTION

Kerala state in India was badly affected by chikungunya fever during 2006–2011. About 63.0% of the human population living in the rubber plantation sector (Kerala contributes to 80.0% of the rubber production in India) was afflicted by the disease (Kumar *et al.*, 2011). Incidence of dengue fever is on an increasing trend in Kerala. All the four serotypes of dengue virus had been reported to be prevalent in the state (Kumar *et al.*, 2013). *Aedes albopictus* (Skuse) 1894 (Diptera: Culicidae), the predominant Aedine species in Kerala was recorded as the vector species of both these arbo-viral diseases (Thenmozhi *et al.*, 2007; Kumar *et al.*, 2008). The immature breeding habitats of this species include the rain water collections in the innumerable discarded (DLCC) and fixed (but unused) (FLCC) rubber latex collection containers, tree holes, leaf axils in pine-apple plantations, fallen leaves of areca-nut plantations etc. in the plantation sector of Kerala (Sumodan, 2003; Kumar *et al.*, 2011).

As no preventive vaccines or effective chemotherapeutic measures are available for these arbo-viral infections, vector control remains the main strategy towards control of these diseases. Control of the vector mosquitoes employing environmentally safe, effective and appropriate tools (Maheswaran & Ignacimuthu, 2012), remains the most suitable strategy towards Integrated Vector Management for these diseases. Biological control is given utmost importance, alternative to chemical insecticides, which are harmless to non-target organisms as well as humans (Amer & Mehlhorn, 2006; Arjunan *et al.*, 2012). Sustainable methods such as pathogens, parasites or predators are highly recommended due to their environmental advantage over chemical control.

While carrying out investigations to elucidate the epidemiological and entomological factors involved in the outbreak of chikungunya/dengue fevers in the rubber plantation region of Kerala, we came across the occurrence of a predacious diving beetle in the water holding FLCCs and DLCCs, in one of the villages, Aimcompu (09º 46.477' N; 76º 41.113' E), in Kottayam district during 2008. The Coleopteran beetle was taxonomically identified as *Platynectes* sp. (Family: Dytiscidae) by the Natural History Museum, London (Fig. 1). Further, field investigations revealed natural occurrence of this species in other rubber plantation areas, selected for the entomological surveillance programs, viz., Pampady (09º 32.457' N; 76º 38.953' E) in Kottayam District and Chethackal (09º 26.241' N; 76º 48.440' E) in Pathanamthitta District. Hence, we carried out a systematic study to determine the predatory potential of *Platynectes* sp. against the vector *Ae. albopictus* in the rubber plantations and the findings are reported here.

MATERIALS AND METHODS

Prevalence of *Platynectes* sp.

FLCCs and DLCCs in rubber plantations in 3 selected villages: Aimcompu, Pampady and Chethackal in Kerala state were surveyed for the natural prevalence and population density of *Platynectes* beetles for a period of one year (2011-2012). 200 rubber trees were covered in each village, once in a fortnight. These were selected in 4 radials from fixed points, covering about 50 trees on a radial. The total area covered using this sampling procedure was about 20 ha of rubber plantations, in each village. These three villages were selected as these were worst affected by chikungunya outbreak during 2007 and they represented both large and small scale rubber plantations.

Laboratory maintenance of *Platynectes* sp.

Specimens of *Platynectes* sp. were collected from FLCCs and DLCCs in rubber plantations during the monsoon season. They were maintained in laboratory in 2.5 ft X 1.5 ft enamel trays with water and mud. To simulate natural breeding habitats, *Epiphyllum angulier* found to be growing profusely in the natural habitats was planted on the mud in the trays. The beetles were fed with immature mosquitoes in the laboratory. From this facility, the required number of beetles was used for the laboratory experiments and field trials.

Laboratory Bio-assays

To estimate the maximum number of *Ae. albopictus* larvae a beetle could devour per day, two independent experiments (in triplicates) maintaining negative controls were performed in the laboratory by introducing (i) one beetle in an enamel tray

Figure 1. *Platynectes* sp. adult specimen (The divisions in the scale shown below equals 1 mm)

of 1' X 1' with 500 ml water and 30 third instars of *Ae. albopictus* and (ii) five beetles in 2.5' X 1.5' enamel tray with 2500 ml of water and 150 third instars of *Ae. albopictus*. These two experiments with different prey densities were carried out, since optimum predator prey ratio was unknown. The number of larvae was replenished each day to maintain the constant prey density in both the experiments. The rate of predation was recorded for 10 consecutive days at an interval of 24 hrs. The clearance rate (CR = number of prey killed / litre/day/predator) had been proposed (Gilbert & Burns, 1999; Aditya *et al.*, 2006), as a better indicator of predatory efficiency since it takes into account the space and duration of the experiment along with the predator/prey ratio. In the current study also, we estimated the clearance rate of *Ae. albopictus* using the formula CR = V (lnP) / TN, where V = volume of water (L), P = Nos. of preys killed, T = time (in days), and N = number of predators.

Field studies

To evaluate the predatory ability of the beetle *Platynectes* sp. in the field conditions, trials were carried out in a rubber plantation at Pampady during June-August, 2011. The required numbers of the diving beetle, *Platynectes* sp. for the field experiments were obtained from the laboratory stock. Three different predator densities were explored for this study using 8, 4 and 2 beetles per LCC. These densities were selected based on the results obtained in the laboratory trials carried out. Ten latex collection cups distributed in about 1 ha area (fitted to rubber tree trunks for collection of latex and where rubber tapping was suspended), containing about 500-700 ml of rain water and which bred *Ae. albopictus* were selected for the study, for each predator density. A negative control of ten containers was also maintained, about one km. away, from the experimental zone. Larval densities in all the LCCs were assessed for ten days (1-10) after the introduction of beetles in an interval of 24 hours. Prior to the introduction of beetles pre-control larval density was observed in all the containers. When a variation in the number of beetles was noted in a LCC (some beetles flew away occasionally), they were replenished from the stock maintained in the laboratory. Data on immature density of the vector in each of the habitat were collected prior to application of the predator through standard measurement methods (Service, 1976). Briefly, the method involved siphoning out of the entire water into an enamel tray held below the tree cups which are above the ground level 3-5 meters and counting various stages (first to fourth instars) of the mosquito. After counting, the entire water with the immatures of the mosquito was returned to the same latex collection containers. The reduction in percentage of *Aedes* larvae after introduction of beetles in field trials was adjusted with control data using Henderson Tilton formula (Henderson *et al.*, 1995).

RESULTS

Natural prevalence of *Platynectes* sp.

The prevalence of the *Platynectes* beetle population was found to be comparatively higher in Aimcompu than in the other two areas. The average prevalence rate (22.68%) and density (2.23) of the beetles (Table 1) were found to be maximum during September (South West Monsoon season). Highest prevalence rate was recorded in Aimcompu village (49.62%). Beetles were not found prevalent in the containers from January to April. The re-occupation of beetle in containers commenced during the month of May, when intermittent rainfall ensued prior to the onset of monsoon season.

Predatory potential of *Platynectes* sp.

The average consumption of *Ae. albopictus* per beetle per day was estimated to be 17.75 + 5.0 in the laboratory. The beetle captured *Ae. albopictus* larvae by its forelegs on the thorax, masticated the prey and discarded the carcasses in 20-30 seconds (Fig. 2), while the larvae of the beetle sucked body fluids of the prey and discarded the exoskeleton. The average clearance rate was estimated to be 2.15. Third larval instars of the beetle were also found predatory to *Ae. albopictus* larvae.

In the field experiments (n = 40), the average density of *Ae. albopictus* larvae per

Table 1. Prevalence and density of *Platynectes* beetles in rubber plantation areas through different months in Kerala

Months	Prevalence of Beetles (%)				Density of Beetles Per Positive Container			
	Aimcompu	Chethackal	Pampady	Average	Aimcompu	Chethackal	Pampady	Average
Aug	49.62	17.76	15.38	22.63	3.00	1.95	1.57	2.27
Sep	27.48	24.39	14.18	22.68	3.80	1.85	1.70	2.34
Oct	1.76	1.50	0.68	11.6	1.66	1.00	1.00	1.40
Nov	4.39	0	10.00	1.92	1.25	0	1.50	1.60
Dec	0	0	1.81	1.75	0	0	1.00	1.00
Jan	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0
May	8	0	0	1.23	2.50	0	0	2.50
Jun	4.05	5.76	0.83	2.66	1.55	1.45	1.00	1.47
Jul	15.59	3.12	7.80	14.28	1.54	2.00	2.10	1.75

Figure 2. Adult specimens of *Platynectes* sp. feeding on *Aedes albopictus* larvae in laboratory conditions

LCC was recorded to be 49.45, one day prior to release of beetles. In the LCCs where 8 beetles were introduced, none of the larvae could survive on the 4th day post-release (Fig. 3). *Ae. albopictus* larvae thrived in LCCs where in four and two beetles were introduced until 8th and 9th days respectively. A significant reduction in larval densities (p = 0.0017 and 0.0043 for 8 and 4 beetle releases respectively) was observed on the first day post-release. However, with two beetles, a significant reduction (p = 0.0025) in the larval density was recorded only from the second day of its introduction. No predator mortality was recorded during these field trials in the LCCs.

DISCUSSION

Predatory role of different organisms on mosquitoes had been investigated by many researchers. Dytiscid diving beetles were reported to be the most effective and dominant predators of mosquito larvae in the wetlands and rice fields (Takagi *et al.*, 1996

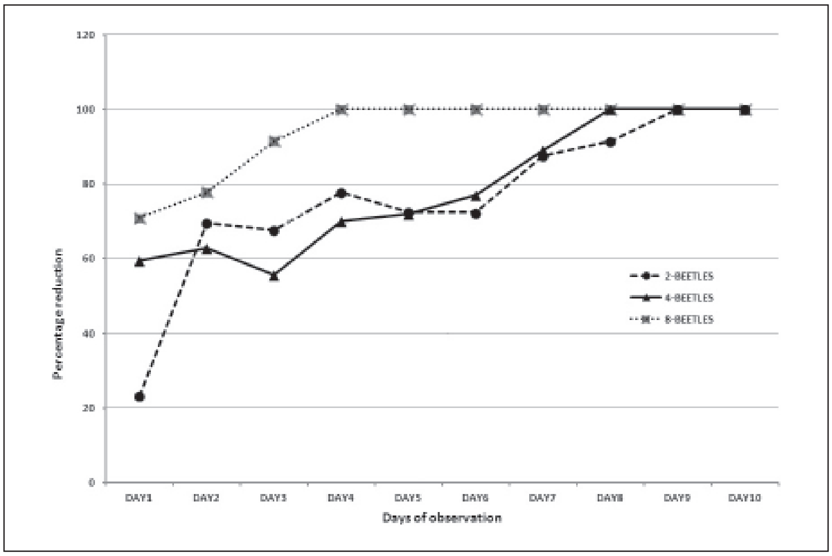

Figure 3. Reduction of *Aedes albopictus* larvae (in percentages) after introduction of beetles in their breeding habitats in the field conditions.

Lundkvist *et al.*, 2003; Chandra *et al.*, 2008; Culler & Lamp, 2009). *Rhantus* sp, *Agabus* sp. and *Hydroporus* sp. are known to prey upon mosquito immatures and considered as biological control agent of mosquitoes (Lee, 1967; Nilsson *et al.*, 1988; Aditya *et al.*, 2006). Larvae of *Acilius sulcatus* (Family: Dytiscidae) had a significant predatory potential on various species of *Anopheles*, *Culex* and *Armigeres* prevalent in cement tanks in West Bengal, India (Chandra *et al.*, 2008).

Only 2-3 species of *Platynectes* had been recorded from India so far (Ghosh & Nilsson, 2012). These were recorded from mostly North India. Also, literature on the ecology and bionomics of these species is very scanty. *Platynectes* beetles are predatory beetles inhabiting streams and riverine swamps as well as in irrigation ditches (Balke *et al.*, 2002). We report for the first time, the wide spread occurrence of *Platynectes* sp. in rubber plantations in Kerala. The natural habitat of the beetle was found to be the water bodies such as fresh water ground pools and pits in the rubber plantations. They invade the rubber latex collection containers, fixed at 3.5 to 6 m above from the ground level, which support abundant breeding of *Ae. albopictus* from the month of May. Our studies show that the beetles are predatory to *Ae. albopictus* immatures and 8 beetles could clear off the immature breeding of *Ae. albopictus* in the LCCs on the fourth day of post release, whereas 4 and 2 beetles caused a reduction of 100 and 91.42 percentages respectively on the 8th day of observation, the approximate larval duration of *Ae. albopictus*. As the average number of beetles recorded per LCC was found to be 2.34 under natural conditions, we conclude that the natural population of beetles indeed played a significant role in the control of the vector population in rubber plantations of Kerala. The present study also evinces the potential of utilizing this diving beetle *Platynectes* sp. as a bio-control agent in an Integrated Vector Management (IVM) strategy against dengue and chikungunya, in rubber plantations of Kerala.

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