Short Communication

Odonate Nymphs: Generalist Predators and their Potential in the Management of Dengue Mosquito, *Aedes aegypti* (Diptera: Culicidae)

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Abstract

Background: Dengue is amongst the most serious mosquito-borne infectious disease with hot spots in tropical and subtropical parts of the world. Unfortunately, no licensed vaccine for the disease is currently available in medicine markets. The only option available is the management of dengue vector mosquito, *Aedes aegypti* (Diptera: Culicidae).

Method: Predatory potential of five odonate nymphs namely *Anax parthenope, Bradinopyga geminate*, *Ischnura forcipata*, *Rhinocypha quadrimaculata*, and *Orthetrum sabina* were evaluated against the 4th instar larvae of the dengue vector mosquito, *Aedes aegypti*, under laboratory conditions. The consumption of the mosquito larvae was evaluated at three water volume levels viz., 1 liter, 2 liter and 3 liter.

Results: The number of *Ae. aegypti* larvae consumed varied significantly among the five species, and at different levels of water volume ($P< 0.01$). However, the interaction between odonate nymphs and the water volumes was statistically non-significant ($P> 0.05$). *Ischnura forcipata* consumed the highest number of *Ae. aegypti* larvae (n=56) followed by *A. parthenope* (n=47) and *B. geminate* (n=46). The number of larvae consumed was decreased with increasing search area or water volume, and the highest predation was observed at 1-liter water volume.

Conclusion: The odonate nymphs could be a good source of biological agents for the management of the mosquitoes at larval stages.

Keywords: Biological control, Dragonflies, Damselflies, Mosquitoes, Dengue vectors

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Introduction

Dengue is amongst the most serious mosquito-borne infectious disease with hot spots in tropical and subtropical parts of the world. Unfortunately, no licensed vaccine for the disease is currently available in medicine markets (Kovendan et al. 2012). The only option available is the management of the mosquito, *Aedes aegypti* (Diptera: Culicidae), which is a vector of deadly diseases like dengue fever, chikungunya and yellow fever (Khan and Akram 2013). Different chemical measures such as indoor residual sprays, larviciding, insecticide treated bed nets and fogging are prioritized for the management of dengue mosquitoes worldwide (Zia et al. 2012), however, these measures are linked with serious environmental concerns like the development of insecticide resistance and environmental pollution (Bilal et al. 2012). Moreover, recent reports on the development of insecticide resistance in different mosquito species including dengue vector mosquitoes (Khan et al. 2011, Rathore et al. 2013) stress the need to explore alternate measures. Naturally, occurring aquatic predators have been assumed a significant ecological factor in regulating different mosquito species. For example, the predators such as amphibians (Ohba et al. 2010), copepods (Marten and Reid 2007), crustaceans (Su and Mulla 2002), odonates (Mandal et al. 2008), water bugs (Aditya et al. 2004), wolf spiders (Futami et al. 2008) and

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backswimmers (Rodriguez-Castro et al. 2006) have shown their tendency to feed on and regulate different mosquito species in aquatic habitats like ponds and paddy fields (Kweka et al. 2011).

Of these stated predators, odonates (Insecta: Odonata) have been explored less for their predatory potential both in the Asian and world perspective (Mandal et al. 2008). To the best of authors' knowledge, aquatic predators, particularly odonate nymphs have not been explored to much extent against mosquitoes in Pakistan. The odonate nymphs usually co-exist with many mosquito species immatures, and their long nymphal stage (1 year or more) and competitive predatory ability (Corbet 1980), offer a good opportunity to use them as biological agents.

Therefore, the present study focused on the comparative evaluation of predatory potential of the different odonate nymphs against the larvae of *Ae. aegypti*. The results presented provide a baseline for the field experiments, and possibility to include these predators in environment friendly management plans for the mosquito control.

Materials and Methods

A field collected population of *Ae. aegypti* from Lahore (31° 32′ 59 N; 74° 20′ 37 E) was reared under laboratory conditions (25± 2°C, 65± 5% RH) as described previously (Khan et al. 2011). Briefly, the mosquito larvae and adults were collected from artificial containers and natural habitats and reared in the laboratory by standard rearing procedures. The larvae were reared in steel trays approximately 3 inch deep and fed on Tetramin (artificial diet) until the adults emerged. Early-instar naiads/nymphs of five odonate species (Insecta: Odonata) namely *Anax parthenope* (Family Aeshnidae), *Bradinopyga geminate* (Libellulidae), *Ischnura forcipata* (Coenagrionidae), *Rhinocypha quadrimaculata* (Chlorocyphidae), and *Orthetrum sabina* (Libellulidae) were collected from ponds and rice fields by using aquatic dip nets. The nymphs were identified by following Fraser (1933), Anjum (1997) and Nesemann et al. (2011), and were kept in distilled water under the laboratory conditions. Before predation experiments, the nymphs were provided Chironomid larvae for feeding.

A feeding bioassay was performed by following the methodology of Mandal et al. (2008) with some modifications. Before starting the experiment, the nymphs were starved for a period of 6 hours. A single nymph of each odonate species was introduced into water bowl (4-liter capacity) containing distilled water and one hundred 4^{th} instar larvae of *Ae. aegypti*. The consumption rate of the nymphs was evaluated at three different water levels viz., 1 liter, 2 liter and 3 liter, and the number of mosquito larvae consumed was noted after 24 h of the introduction of the nymphs into the bowl. The experiment was replicated at six different times, using the new nymphs and mosquito larvae.

All the data on consumption rate by the odonate nymphs at three different water levels were analyzed by 2-way analysis of variance using the software Statistix 8.1v (Analytical software 2005) and means were compared with the least significant difference test. P< 0.005 was considered signifant.

Results

The number of *Ae. aegypti* larvae consumed varied significantly among the five species of odonate nymphs (F= 144.30, df= 4, 75, P<0.001), and at different levels of water volume (F= 18.32, df= 2, 75, P< 0.001). However, the interaction between odonate nymphs and the water volumes was statistically non-significant (F= 0.32, df= 8, 75, P=

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0.96). *Ischnura forcipata* consumed the highest amount of *Ae. aegypti* larvae (55.89) followed by *A. parthenope* (47.22) and *B. geminate* (46.06) (Fig. 1). The number of larvae consumed by different odonate species was decreased with increasing search area or water volume. The highest consumption of the larvae was observed at 1 liter water volume (46.90) followed by 2 liter (44.56) and 3 liter (42.27) volumes (Fig. 2).

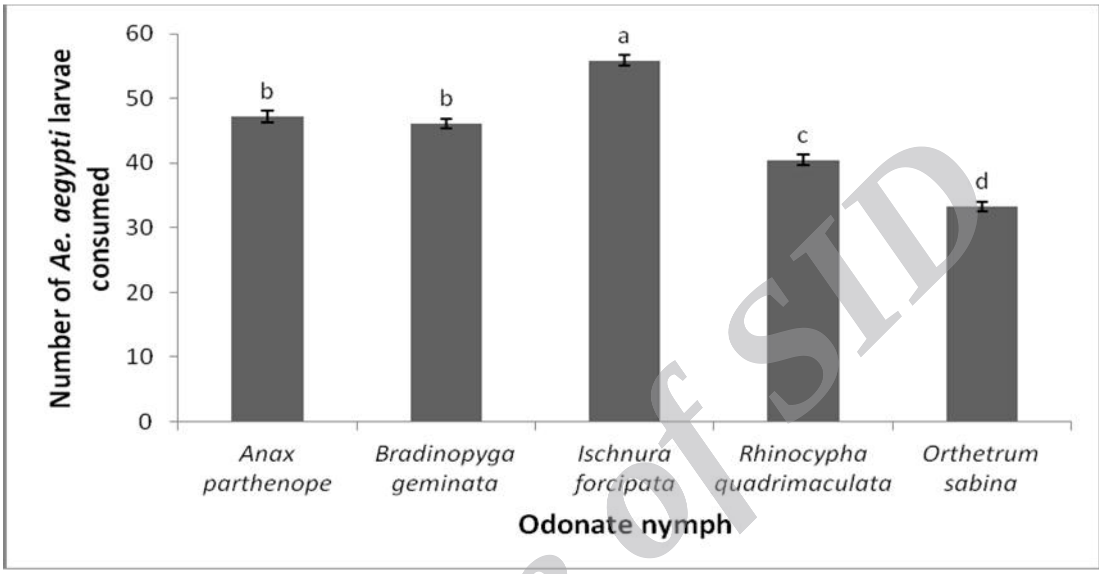

Fig. 1. Rate of consumption of 4th instar *Aedes aegypti* larvae by different odonate nymphs

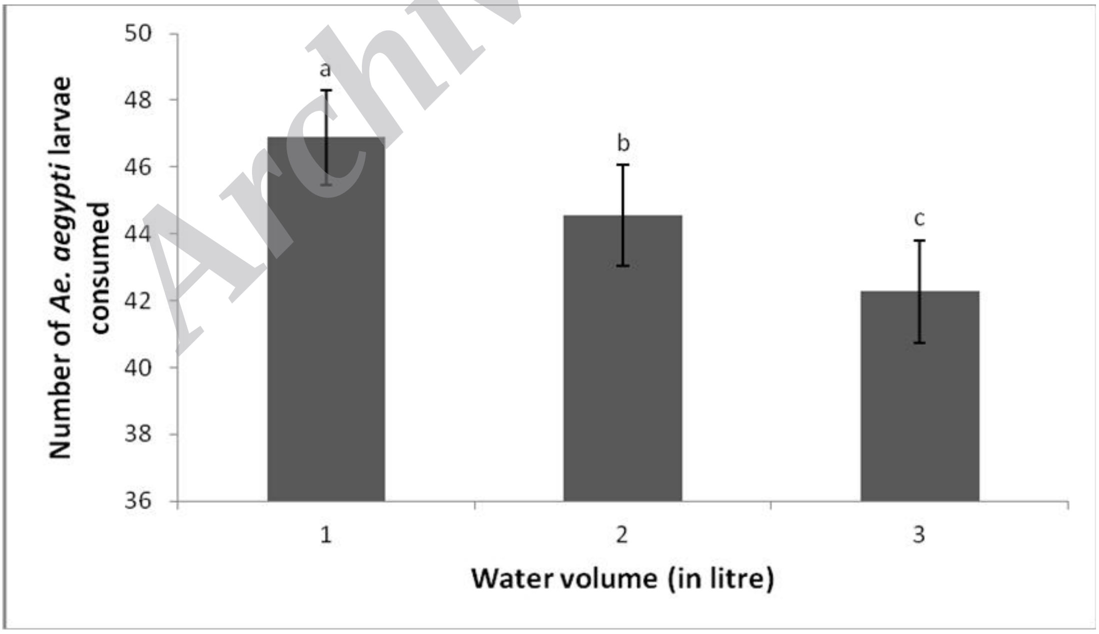

Fig. 2. Cumulative effect of different different water volumes on the consumption rate of 4th instar *Aedes aegypti* larvae by different odonate nymphs

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Discussion

In the present study, predatory potential of five different odonate nymphs has been evaluated. The predator-prey relationship could have a significant impact in an ecosystem by affecting population dynamics and energy flow through food webs. Predators could affect prey populations directly through prey consumption (Khan et al. 2012). The only mosquito species, which have been investigated in the present study, is *Ae. aegypti*.

Recently this species along with *Ae. albopictus* played havoc in different parts of Pakistan. To manage these pests different measures have been adopted with the major focus on chemical control. Resultantly, occurrence of field evolved resistance in mosquitoes and other public health pests have been reported which stressed the need to explore alternate management tools (Khan et al. 2011, Khan et al. 2013).

In the present study, predatory potential of five different odonate nymphs has been evaluated. The results showed that the nymphs were able to consume *Ae. aegypti* voraciously, however, increasing the volume of water had a negative effect on the consumption rate, perhaps due to the evasion tactics of the mosquito larvae (Bhattacharjee et al. 2009). Since *Ae. aegypti* mosquitoes usually lay eggs and complete immature stages in small water volumes (Vezzani et al. 2005), the findings of the study are of worth importance. Previously, some researchers have evaluated the potential of odonate species against different mosquito species (Mandal et al. 2008, Kweka et al. 2011) but such studies are rare in Pakistan. Our results are in agreement with those of Mandal et al. (2008) who evaluated different species of odonates against *Cx. quinquefasciatus* and found that *I. forcipata* was the most voracious feeder of the mosquito larvae. They further reported that the volume of the water had a negative impact on predation efficiency.

The negative effect of increasing water volume has also observed with hemipteran bug species (Saha et al. 2008) and larvivorous fish species (Ghosh et al. 2005, Bhattacharjee et al. 2009). With increasing water volume, the aquatic predators possibly required more time to search, capture and ultimately consume the mosquito larvae (Ghosh et al. 2006). In Myanmar (Sebastian et al. 1990) and India (Mandal et al. 2008) the augmentative releases of different odonate species have regulated *Ae. aegypti* and *Cx. quinquefasciatus* mosquitoes, respectively. The lengthened developmental time of odonate nymphs (i.e. 1 year or more from egg to adult) and predation ability (Corbet 1980) provide an opportunity to use these predators in the management plans designed for *Ae. aygypti*.

Conclusion

Keeping in view the high consumption rate of the larvae per 24 h, these predators could be assumed to feed on a good number of *Ae. aegypti* larvae during their long nymphal stage. Although the species used in the present study varied in their consumption rate, all of the species could be considered for inclusion in the management plan. However, there is a need to explore the predatory potential of the species in the field and in different ecological zones.

Acknowledgements

The authors declare that there is no conflict of interests.

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