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Dragonflies: A comprehensive review of their predatory role in ecosystem dynamics

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Abstract

Mosquitoes are classified within the order Diptera, with the primary vector species belonging to the genera *Aedes*, *Culex*, and *Anopheles*. These mosquitoes serve as carriers of various pathogens, including bacteria, viruses, and parasites. Recent estimates indicate that approximately 700 million individuals globally suffer from mosquito-borne illnesses, leading to over one million fatalities annually. Among these, *Anopheles* mosquitoes are the primary vectors of malaria. Meanwhile, species within the *Aedes* and *Culex* genera are responsible for transmitting various arboviral diseases to humans. According to the World Health Organization (WHO) guidelines, vector control remains the cornerstone of mosquito-borne disease prevention. The most widely used approach for vector control involves the application of chemical insecticides. However, the effectiveness of chemical insecticides is increasingly compromised due to the development of resistance among mosquito populations. Consequently, there has been a shift towards eco-friendly vector control strategies. This study synthesizes relevant information on environmentally sustainable mosquito control techniques, drawing from extensive searches of scientific databases, including Web of Knowledge, Scopus, and Google Scholar. The findings underscore the significance of biological control as an effective and environmentally friendly approach. This method utilizes natural predators and microorganisms to manage mosquito populations. One promising predator is the dragonfly, which preys on mosquitoes and significantly reduces their populations in outdoor environments. While dragonflies may appear intimidating due to their biting behavior, they pose no threat to humans and are highly effective against mosquitoes. Research conducted globally highlights the potential of dragonflies in controlling mosquito species such as *Aedes*, *Culex*, and *Anopheles*. The artificial breeding and systematic release of dragonflies for biological control represent a practical and sustainable solution for managing mosquito vectors on a global scale.

Keywords: *Aedes, Anopheles,* arboviral diseases, *culex,* dragonfly, eco-friendly, mosquitoes and resistance

Introduction

In aquatic ecosystems, bioindicators-organisms or communities with functional traits that respond predictably to specific environmental changes-are among the most effective tools for assessing anthropogenic impacts (Silva *et al*., 2010) [21]. These bioindicators can detect habitat changes at various spatial and temporal scales, including alterations in land use (Ometo *et al*., 2000) [15], riparian vegetation (Monteiro-Júnior *et al*., 2013; Oliveira Junior *et al*., 2015) [12,14], habitat complexity (Weigel *et al*., 2003) [24], and the physical and chemical characteristics of water (Anjos and Takeda, 2005) [3].

Insects of the order Odonata serve as particularly reliable bioindicators for evaluating aquatic environments. These insects inhabit the transitional zone between aquatic and terrestrial ecosystems and are highly responsive to environmental disturbances (Carvalho *et al*., 2013; Monteiro-Júnior *et al*., 2013; Oliveira Junior *et al*., 2015) [4, 12, 14]. Odonates are also exceptionally diverse in tropical regions (Kalkman *et al*., 2008) [9]. Furthermore, there is considerable variation within the order regarding the ecophysiological requirements of different species (De Marco *et al*., 2015) [7], and changes in local environmental conditions can lead to predictable shifts in odonate community structures (Monteiro-Júnior *et al*., 2013) [12].

The disruption of riparian vegetation, in particular, significantly affects adult odonate community structures. Ambient temperature, influenced by riparian vegetation, directly impacts species occurrence and reproductive cycles (Samways and Steytler, 1996) [17]. Such disturbances can also hinder reproductive behavior and mate selection, as females tend to choose males that secure optimal oviposition sites within riparian zones (De Marco and Resende, 2004) [6]. Dragonflies possess sharp teeth on their jaws, which aid in their predatory behavior. Current research identifies approximately 7,000 species of dragonflies worldwide. Both the nymph and adult stages of dragonflies are recognized as effective mosquito predators. Adult dragonflies capture mosquitoes using their legs, which function as a scoop, and consume them. They are commonly observed flying near freshwater habitats on sunny and warm days. Studies suggest that nymphs can survive for up to five years, while the lifespan of adult dragonflies varies depending on the species. Dragonflies belong to ten families, with Libellulidae being the largest, comprising 140 genera and approximately 962 species. This

cosmopolitan family, believed to be the most recently evolved, represents about a quarter of all known living Odonata species. Dragonflies are also known for their extensive migrations, covering significant distances across the globe, making them the longest migratory insects. Their remarkable speed and agility in flight contribute to their status as highly efficient aerial predators.

Several dragonfly families, including Corduliidae, Aeshnidae, Libellulidae, Cordulegastridae, and Gomphidae, are recognized for their predatory role. Adult dragonflies feed predominantly on mosquitoes, significantly reducing their populations. A single adult dragonfly can consume hundreds of mosquitoes daily. Their legs form a basket-like structure that helps them capture prey mid-flight, after which they crush it into a slurry before ingesting it with their mandibles. Adult dragonflies are adept at catching flying insects such as gnats, mosquitoes, mayflies, moths, bees, ants, termites, butterflies, and other similar organisms. Their flight patterns resemble a helicopter's movements, enabling them to hover, dart, and change direction with ease. Mosquitoes constitute a significant portion of their diet, with larger dragonflies capable of preying on larger insects (Acquah-Lamptey *et al*., 2018) [1]. Adult dragonflies can consume an amount of food equivalent to 15% of their body weight daily, often feeding on mosquitoes during the daytime when these insects hide in bushes or timberlines (Vershini and Kanagapan, 2014) [23]. In aquatic environments, dragonfly nymphs feed on mosquito larvae, making them particularly effective at reducing mosquito populations during this life stage (Akram and Ali, 2018, Mary, 2013) [2, 11]. During the day, adult dragonflies hunt for mosquitoes while basking in sunlight, often perched on flat rocks. Their predatory behavior plays a vital role in controlling mosquito populations across various habitats.

Nymphs typically capture prey by extending their specialized mouthparts. The duration of the nymphal stage varies between 9 and 17 stages, depending on the species. Different odonate species exhibit variation in their nymphal stages. In arid conditions, dragonflies tend to have a single generation per year, whereas in tropical environments, they may produce multiple generations, with the number influenced by habitat conditions. During the nymph stage, water is drawn into the abdomen and expelled, a process that facilitates movement and respiration. Nymphs absorb oxygen from the water through gills located in their abdomen. They pump water in and out through the anus to assist in oxygen intake. Typically, there are 6 to 15 nymphal stages before reaching adulthood. Adult dragonflies, which prey on mosquitoes and midges, have a lifespan of about a month. Their legs are adapted for catching mosquitoes and scooping prey during flight. Dragonflies thrive in environments with stable oxygen levels and clean water, making them valuable bioindicators for environmental and ecosystem health. Nymphs display various behaviors, such as acting as sprawlers, burrowers, hiders, or claspers, depending on their microhabitats. The specific microhabitat occupied influences their body shape, metabolic activity, and respiratory processes.

Fossil evidence suggests that dragonflies date back to the Carboniferous period, with some specimens displaying wingspans exceeding one meter, resembling a modern hawk in appearance. In their adult stage, dragonflies possess a bristle-like body structure.

A defining feature of dragonflies is their large compound eyes, which cover a significant portion of their head and provide exceptional vision. They are equipped with four membranous wings that contain a network of veins and cross-veins. Pigment cells on the wings play a crucial role in species identification. The hind wings are broader at the base compared to the forewings, and the abdomen is both long and slender. Dragonflies' compound eyes are highly developed, consisting of approximately 30,000 facets, each functioning as an independent light-sensing unit known as an ommatidium. This sophisticated eye structure grants them nearly a 360° field of vision, making their eyesight remarkably advanced and suited for detecting prey and navigating their environment.

Many male dragonflies exhibit territorial behavior, actively defending their territories against other creatures, including other dragonfly species. After females lay eggs, males typically establish and defend territories around favorable oviposition sites, ensuring the breeding areas are protected from competing males and other animals.

During mating, dragonflies form a characteristic mating wheel. This is facilitated by a secondary sexual organ located on the second segment of the male's abdomen. The mating wheel is created when the male clasps the female behind the head, and the female raises the tip of her abdomen to contact the male's secondary genitalia. Dragonflies are also capable of flying in tandem while in this formation. The adult stage of dragonflies lasts about 6 to 8 weeks during the summer months, during which they are highly active hunters. Prey is captured mid-air using their legs and consumed while in flight. Dragonflies are efficient predators, capable of consuming large numbers of mosquitoes and other small flying insects. This predation makes them highly beneficial insects in controlling mosquito populations (Saha *et al*., 2012) [16]. Dragonflies face predation from a variety of organisms, including birds, amphibians, spiders, wasps, lizards, small rodents, other odonates, adult Ceratopogonidae, and carnivorous plants such as sundews. Despite these threats, their role as effective mosquito predators contributes significantly to their ecological value. The World Health Organization reports that over half the global population is at risk of vector-borne diseases.

Materials and Methods

In this study, all relevant information related to the research topic was gathered from online sources and incorporated into this paper. A comprehensive review of scientific literature was conducted using databases such as Web of Knowledge, Scopus, and Google Scholar.

Results and Discussion

Numerous studies have reported on the effectiveness of dragonflies in controlling mosquito populations (Jacob *et al*., 2017) [8]. In one study, odonate nymphs were released to target *Aedes aegypti*, the primary vector of dengue. The introduction of these dragonfly nymphs significantly reduced mosquito larval production, contributing to the control of dengue outbreaks. The longevity of odonates, their predatory behavior, trophic position, and their tendency to lay eggs in mosquito habitats during their

immature stages are key factors that make them valuable for biological mosquito control.

Mandal *et al*. (2008) [10] conducted an experiment under semi-field conditions using five odonate species in West Bengal, India. The results showed a notable reduction in mosquito larval density 15 days after their introduction. Specifically, the nymphs of *Aeshna flavifrons*, *Coenagrion kashmirum*, *Ischnura forcipata*, *Rhinocypha ignipennis*, and *Sympetrum durum* were evaluated. Their study demonstrated that the release of odonate nymphs into mosquito breeding habitats, such as temporary pools or larger water bodies, could effectively decrease mosquito larval populations and serve as a biological resource for vector and pest control.

Another study investigated the efficacy of dragonfly nymphs against *Aedes aegypti* larvae and pupae under laboratory and field conditions (Singh *et al*., 2003) [22]. The results indicated that nymphs act as effective predators, completely eliminating immature mosquito stages within 4 to 9 days, depending on the density of aquatic stages in container habitats. Sebastian *et al*. (1980) [19] reported that dragonfly nymphs of the species *Libellula* sp. eradicated all larval and pupal stages of *Aedes aegypti* within 4 to 9 days. They recommended utilizing dragonfly nymphs as biological control agents for *Aedes* mosquitoes (Shaalan and Canyon, 2009) [20]. In another field experiment, Chatterjee *et al*. (2007) [5] assessed the potential of dragonflies to control the malaria vector *Anopheles subpictus* in concrete tanks in India. Their results revealed a significant decrease in the larval density of *Anopheles subpictus* in dipper samples 15 days after the introduction of dragonfly nymphs. These studies collectively highlight the potential of dragonflies as effective biological control agents for managing mosquito populations.

In a pilot field study by Sebastian *et al*. (1990) [18], dragonfly nymphs were released during the rainy season in Yangon, Myanmar, to suppress *Aedes aegypti* populations. The findings showed a reduction in larval populations within 2 to 3 weeks, with adult mosquito populations declining approximately 6 weeks after the trial began.

Conclusion

More than half of the global population is at risk of vector-borne diseases, as mosquitoes thrive in nearly all regions of the world. Research indicates that Odonata species effectively control mosquito populations, including *Anopheles*, *Aedes*, and *Culex*, during both their adult and larval stages. These mosquito species are significant vectors of diseases that affect humans. Given the increasing resistance of mosquitoes to various insecticides, employing biological control methods has emerged as a suitable strategy within Integrated Vector Management programs (Chatterjee *et al*., 2007) [5]. Consequently, the artificial rearing of these predatory insects and their release in areas affected by mosquito-borne diseases can significantly help in reducing disease transmission.

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All this above information was fetched from the following sources which included authentic books, several research papers and other official websites of the government, several universities. Conveying information to as many agricultural producers as possible is the main objective.

Conflict of Interest

On behalf of all authors, the corresponding author declares that there is no conflict of interest involved. No external funding was received for the research conducted, and there are no financial or non-financial interests to disclose.

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