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The problem of insecticide resistance was outlined with special reference to mosquito vectors control. In the biological control of mosquitoes, vectors of important diseases, dragonflies are of interest as their naiads are active predators of mosquito larvae. However, some species of dragonflies harbor the infective stages of two intestinal flukes, Phaneropsolus bonnei and Prosthodendium molenkampi. The classification, life-history and medical importance of the dragonfly are reviewed.

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*ปัญหาการต้านยาฆ่าแมลงของยุงซึ่งเป็นพาหะนำโรค ทำให้มีการเสาะแสวงหาวิธีอื่นเพื่อนำมาใช้ในการกำจัดและควบคุมยุง วิธีดังกล่าวนี้คือการควบคุมทางชีววิทยาหรือชีวภาพ (**Biological control**) ซึ่งดูเสมือนว่าแมลงปอจะเป็นชีวินทรีย์ (**biocontrol agent**) ที่น่าสนใจมากในการนำมาใช้ทำลายยุง เนื่องจากชีวินทรีย์อื่น ๆ ไม่มีประสิทธิภาพเพียงพอ แมลงปอโดยเฉพาะระยะที่เป็นตัวอ่อน (**naiad**) จะกินลูกน้ำยุงได้อย่างว่องไว นอกจากนี้ในแมลงปอบางชนิดยังมีระยะติดต่อของพยาธิใบไม้ลำไส้ ซึ่งได้แก่ พยาธิ **Phaneropsolus bonnei** และ **Prosthodendium molenkampi** การจำกัดจำพวก วงชีวิต และความสำคัญทางการแพทย์ของแมลงปอได้รวบรวมไว้ในบทความนี้*

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The dragonfly is a large-winged and harmless insect belonging to the order Odonata. It is closely related to the damselflies. More than 5,000 species have been described in over 500 genera. They are distributed throughout the world, but the majority are found in the Oriental and Neotropical regions. No part of the Palaearctic zone contains an abundant or striking dragonfly fauna, excepting Japan.[1]

Classification of the Dragonfly

Dragonflies are beneficial and make an important contribution to biological control. All stages are carnivorous, eating a large number of insects, especially the midges and the mosquitoes. The adult feed during flight, the spiny legs forming a scoop to catch and hold the prey.

Classification of the dragonflies by Fraser 1934,[2] 1936[3] are listed below :-

Phylum Arthropoda
 Class Insecta
 Order Odonata
 Suborder Anisoptera
 Family Gomphinae
 Subfamily Gomphinae
 Subfamily Epigomphinae
 Subfamily Ictininae
 Family Cordulegasteridae
 Subfamily Chlorogomphinae
 Subfamily Cordulegasterinae
 Family Aeshnidae
 Subfamily Jagorinae
 Subfamily Brachytroninae
 Subfamily Aeshninae
 Subfamily Anaxinae
 Family Libellulidae
 Subfamily Corduliinae
 Subfamily Libellulinae

Order Odonata composes of the suborder Zygoptera (damselflies) and Anisoptera (dragonflies). These two suborders are closely related, but they can be distinguished from each other during the larval and adult stages as described in Table 1 and 2.

Table 1 Differences between suborders of Odonata in larval stage.

Zygoptera	Anisoptera
1. Naiads slender with paddle-like caudal gills.	1. Naiads large with rectal gills.
2. Small, Slender and delicate at all stages.	2. Large and robust at all stages.
3. Eggs inserted into stem of aquatic plants.	3. Eggs usually laid on water or surface of aquatic plant.
4. Lack "jet-propulsion" mechanism.	4. Able to propel themselves short distances by forcibly ejecting water from the rectum.

Table 2 Differences between suborders of Odonata in adult stage.

Zygoptera	Anisoptera
1. Wings of equal size, narrow at base and held vertically at rest. Weak fliers.	1. Hind - wings broader at base, held horizontally at rest. Strong fliers.
2. Eyes bulbous, projecting prominently and constricted at base.	2. Eyes not projecting from side of head.
3. Females with developed ovipositors.	3. Most families with reduced or vestigial ovipositors.
4. Males have 4 terminal abdominal appendages.	4. Males have 3 terminal abdominal appendages.

Further distinctions are present in nearly every structure, but especially in the details of the complex wing venation.

There is also a third suborder, the Anisozygoptera known only from a larva; its imago has not yet been discovered. It is to be regarded as a link between the other two suborders.[4]

Life - history of the Dragonflies.

There are three stages in their life - history, the egg, the larva, and the imago or perfect insect. There is a great change in the structure at metamorphosis, but the change from larval to imaginal life being direct.[4] Metamorphosis usually occurs at night, or about dawn.[5] The development usually takes about a year and in the temperate zone the larva is the overwintering stage. The number of instars that intervene between the egg and the imago varies in different species and also among individuals of the same species, ranging from ten to fifteen.[6, 7] The whole nymphal period varies greatly in length, from two years in the genus Aeshna (Anisoptera), to three or five years in other genera. The dragonfly naiads are aquatic and breathe by means by tracheal gills; the second and shorter of its life-cycle is aerial, breathing by means of thoracic and abdominal spiracles.[1, 4]

The three developmental stages were also described by Fraser, 1933[4]; Richards and Davies, 1977.[1]

The Egg. - Exophytic oviposition is characteristic of the Anisoptera, the eggs are either dropped freely into the water or attached superficially to aquatic plants in a gelatinous mass containing as many as 800 eggs. They are round or fusiform, and pale yellow in colour. Oviposition among the Anisopteran, families Aeshnidae and Petaluridae is endophytic. Dragonflies adopting this method have elongated eggs which they insert into slite cut by the ovipositor into stems and leaves of plants or other objects, near or just beneath the water mark.

The larva (naiad). - The egg hatches out as a tiny larvule enclosed in a thin membranous envelope which protects it until it finds a watery environment; this envelope is soon cast off. The newly - hatched pronymph is of extremely brief duration, lasting only a few seconds in Anax (Tillyard) or up to 30 minutes in Sympetrum striolatum.[7] The free nymph which emerages from the pronymph is in its second instar and fully equipped for its future life. The larvae are of varied form, but consistent in possessing a highly specialized labium. This organ lies flush beneath the head and thorax, and possesses, between the mentum and submentum, a hinge at which it is folded into two; it can be extended at will by opening out. It is known as the mask, and is employed in seizing its prey by means of the powerful hooks and jaws situated at its apex. The mask is variable in shape, and this is important from the identification point of view.[4]

In the Anisopterous nymph the body ends in three small processes, a median epiproct or appendix dorsalis and a pair of lateral paraprocts : when closed they form a pyramid which conceals the anus. Respiration takes place by means of concealed rectal tracheal gills. When the time for emergence of the imago is approaching the nymph ceases to feed, appears tense and swollen and raises itself from the water in order to breath air. When the internal changes are complete, the naiad climbs up a suitable object, out of the water and fixes its claws so firmly in position that the exuviae remain tightly adherent to the support long after the imago has flown away.

The Adult. - The insect is made up of a head, a prothorax, thorax and abdomen; the thorax carries a pair of membranous wings and three pairs of legs, the abdomen composes of ten segments carrying the genitalia of the male on the 2nd, 9th and 10th segments, and appendages for seizing the female on the anal side of the 10th.

Medical Importance of the Dragonfly and its role in mosquito control.

The dragonfly became associated with man when it was postulated to serve as the 2nd intermediate host of two intestinal flukes Phaneropsolus bonnei and Prosthodendium molenkampi in northeastern Thailand.[8] It was found that in four species, Crocothemis servilia servilia, Orthetrum sabina, Trithemis pallidinervis and Brachythemis contaminata, both the adult and larval stages harbor infective stages of the parasites. The transmission was ascribed to the habit of eating raw fish by the villagers. Naiads are sometimes mixed with the small shrimps that these people eat while working in the rice-fields.

Nevertheless, the characteristics of these insects being aquatic in their larval stages, show that they serve as predators in the biological control of other insects especially mosquito larvae. Mosquitoes are important vectors of some diseases, as certain species transmit malaria and filariasis. In Thailand many species of Anopheles mosquitoes such as Anopheles balabacensis[9, 10] A. maculatus,[10] A. aconitus[11] and A. Sundaicus[12] are reported as malaria vectors. A. balabacensis balabacensis is an important vector of malaria in South East Asia and the main vector in Sabah, East Malaysia. There are concurrences of drug resistant falciparum malaria in the areas where this vector is found.[13, 14] Many such vectors develop resistance to various groups of insecticides resulting in the failure of control. The problem of insecticide resistance and the growing concern about possible toxic hazards of insecticide residues had stimulated scientists to seek alternative methods of controlling insects. They were grouped as mechanical, physical, chemical (excluding poisons) biological and genetic or a combination of these. The search for alternative agents of biocontrol for the vectors of tropical diseases had been encouraged by the Scientific Working Group,[15] due to the problem of insecticide resistance among the mosquito vectors.

Several studies have reported the effectiveness of larval and pupal predators such as guppies, Gambusia and Toxorhynchites larvae in the control of mosquito larvae. However the effectiveness of these predators as mosquito ingesters or in the control of mosquito-borne diseases obviously have their limits.[16, 17, 18] Bacteria in the genus Bacillus are also employed in the biocontrol of mosquito larvae. Some of these species are B. alvei, B. brevis, B. sphaericus and B. thuringiensis var. israelensis.[19] It is important to have a variety of agents available for biological control. Natural enemies of mosquitoes, especially dragonfly naiads, should therefore be collected and identified, both to broaden our present knowledge of their geographic distribution and to stimulate the discovery of new biocontrol agents. Dragonfly naiads are voracious active predators of mosquito larvae both in nature and under experimental conditions, some ingesting as much as 192 Culex larvae in 19 hours.[20] It was found that some mosquitoes breed in shallow, permanent marches where dragonflies are common,[21] so that these predators became of interest.

In the field of medical entomology, Watanabe et al. 1968[22] listed 7 species of Odonata naiads found in the paddy-field as predators of mosquito larvae. They also indicated that many species of these naiads collected from the field could ingest Culex tritaeniorhynchus summorosus. Phanthumachinda 1978[23] reporting on the biology of aquatic insects, the natural enemies of Aedes aegypti and Culex pipiens fatigans, suggested that the dragonfly naiad could ingest both Aedes and Culex larvae. A report of the daily ingestion rate of Pantala flavescens (Libellulidae) by Young 1921[24] showed that the naiad ate up to 550 Aedes aegypti per day. According to Sebastian et al. 1980[25] the dragonfly naiads could be employed in the biological control of Aedes mosquitoes as they were found to prey on Aedes aegypti larvae and pupae.

Asahina et al. 1972[26] reported on a total of 150 adult dragonflies collected in a paddy field at Bangkhen, Thailand. These were classified into 14 species, five of which belonged to the suborder Zygoptera; the other nine belonging to the suborder Anisoptera were Orthetrum sabina, Brachythemis contaminate, Acisoma panorpoides panorpoiders, Crocothemis servilia servilia, servilia, Diplacodes trivialis, Neurothemis tullia feralis, Neurothemis intermedia atalants and Trithemis pallidinervis. All of these dragonflies were common lowland species in continental Southeast Asia. They were presumed to have two or three generations a year, and their immature stages were found in stagnant waters within and around rice fields. Major and common Odonata species of paddy fields in Thailand were described by Makao et al. 1976[27]. Neurothemis tullia, Diplacodes trivialis and Orthetrum sabina were mentioned as the commonests.

As considerable advances have taken place in the field of biological control, at present to discover if dragonfly naiads are one of the useful biocontrol agents of mosquito larvae is of interest. The selection of the most promising and most common naiads in nature is the first step and when possible, the breeding of these species should be done in the laboratory. Experiments should be carried out to determine feeding habits in order to determine the suitable time for release into the natural breeding places of mosquitoes. These works would be of great value in furthering vector control.

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