Nature Watch

When Dragons Fly ...

K A Subramanian

K A Subramanian works at the Centre for Ecological Sciences, Indian Institute of Science, Bangalore. He is currently working on the community ecology of stream insects of the Western Ghats and is interested in insect diversity and conservation

A Natural History of Odonata

We have all held them by their wings, made them lift pebbles from our palms, tied their tails to paper flags and watched them fly away, wondering all the while where and how they lived and what they did. I only knew that we called them dragonflies and they were of endless variety, of all shades and colours, with some being nasty biters and others delicate beauties. This is a natural history account of one of the most common types of insect, dragonflies, which usually enter our home at night, buzzing around lights, and nose diving to the floor.

The Order Odonata of Class Insecta, comprising sub orders Anisoptera (dragonflies), Anisozygoptera and Zygoptera (damselflies) contains some of the most common insects flying over our ponds and rivers. About 5,000 extant species are distributed all over the world, with India possessing about 500 known species. Odonata are one of the ancient orders of insects and first appeared during the Carboniferous era (*Figure* 1), about 285 million years ago, along with mayflies (Ephemeroptera). Odonata of the Carboniferous era were giants. For example, *Meganeuropsis americana* from that era had a wingspan of 71 cm. Odonata and Ephemeroptera were the first groups of insects to develop wings and venture into the air. Dragonflies mastered the art of flying and continue to be the masters of the air among insects.

Figure 1. Mesuropetala koehleri (Hagen, 1848), Upper Jurassic, Solnhofen, Germany, coll. U. Resch (Clausthal-Zellerfeld, Germany) (the only known fossil dragonfly tandem!)

Source: http://ww.bechly.de/tandem.htm Photographer: Günter Bechly, Böblingen, Germany.

Based on morphology, the order Odonata is divided into three groups, *viz*. damselflies (Zygoptera), Anisozygoptera and dragonflies (Anisoptera). The suborder Anisozygoptera contains only two species of living fossils, of which *Epiophlebia laidlawi* is known from Darjeeling. Dragonflies and damselflies can easily be distinguished (*Table* 1, *Figures* 2-5). Though they differ

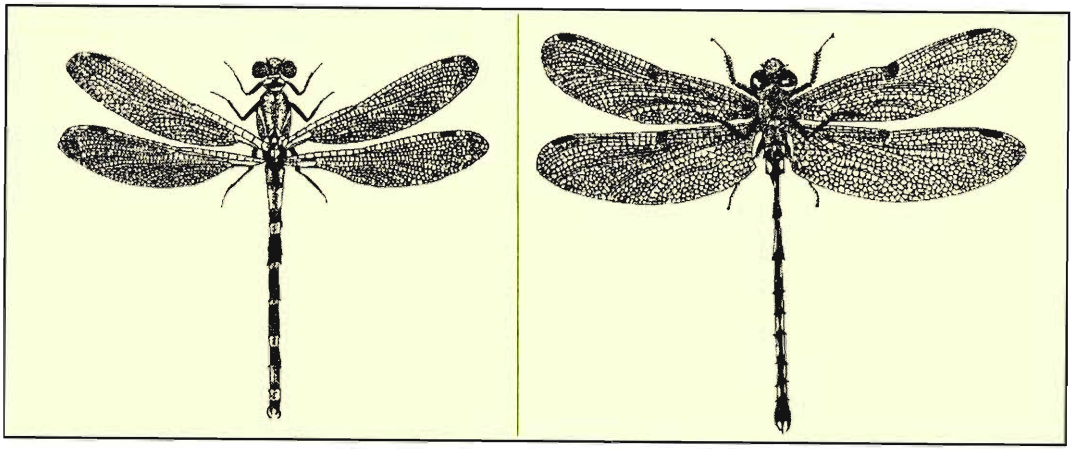


Figure 2 (left). Damselfly, top view.
Figure 3 (right). Dragonfly, top view.

Keywords
Dragonflies, biodiversity, wetlands, damselflies.

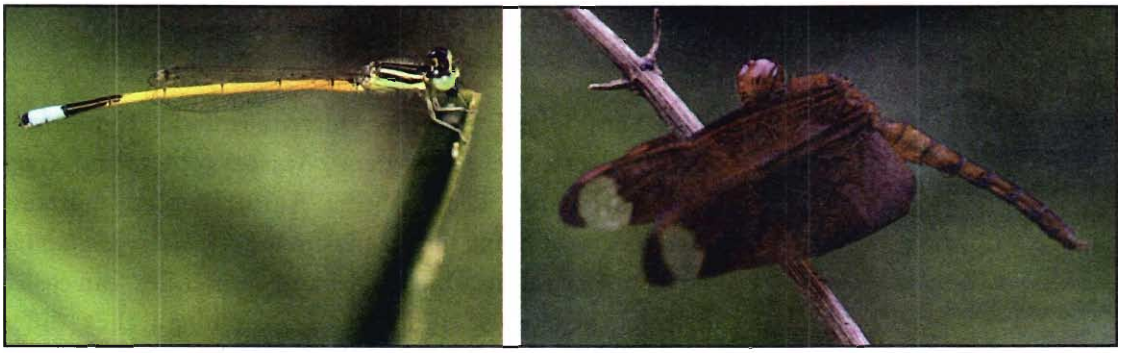
significantly in morphology, their general life history is comparable, and so they are treated together in this article.

Odonates are primarily aquatic in their pre-adult stages and their life is closely tied with flowing and stagnant water bodies. Even though species are usually highly specific to a habitat, some have adapted to urbanization and use man-made water bodies. This habitat specificity has an important bearing on the distribution and ecology of odonates. Species using restricted habitats like hill streams tend to be narrowly distributed, as compared to pool breeders, which are widespread.

Eggs

Odonates lay their eggs in a wide range of aquatic habitats, from damp soil to thundering waterfalls, which tend to be species specific (*Figure* 6). Females select the egg-laying site mainly by

Figure 4 (left). An adult damselfly (Zygoptera), Ischnura delicata.
Figure 5 (right). An adult dragonfly (Anisoptera), Neurothemis fluvia.



Damselflies (Zygoptera)	Dragonflies (Anisoptera)
Adults (*Figures* 2 and 4)	**Adults (*Figures* 3 and 5)**
1. Forewings and hindwings approximately the same size and shape.	1. Forewings and hindwings unequal in size; hind wings broader at base than fore wings.
2. Wings held together dorsally over thorax and abdomen.	2. Wings spread out at rest.
3. Comparatively weak fliers	3. Strong agile fliers.
4. Eyes widely separated.	4. Eyes set close and they meet above head.
Larva (*Figure* 7)	**Larva (*Figure* 8)**
1. Slender, fragile body.	1. Stout, robust body.
2. Three gills at the end of abdomen, visible externally.	2. Gills not visible externally.
3. Lacks 'jet-propulsion'.	3. 'Jet-propulsion' is achieved by ejecting water through rectum.

Table 1. Differences between dragonflies and damselflies.

physical characteristics such as length of shoreline. Species breeding in rivers prefer long straight shores. It is observed that long straight shores of some lakes tend to be colonised by otherwise riverine species. Visual cues also play an important part in oviposition. It has been observed that many pool breeders are deceived by smooth shining surfaces, such as bonnets of cars and wet roads and they try to lay their eggs in these unnatural sites.

Figure 6. Copera vittata egg laying. Note how the male holds female while laying egg.

Damselflies insert their elongated and cylindrical eggs into a plant body. Their elaborate ovipositor is serrated and adapted for making incisions in the tissues of plants and placing the eggs in them. Some are generalists, while others are specific in their selection of the plant for egg laying. For example, *Aeshna viridis* lays eggs only in *Stratiotes aloides*. Host specific associations sometimes effectively determine the distribution of species such as that of *Coenagrion armatum* in Britain which is closely associated with the host plant *Hydrocharis morsusrane*. Small Hymenoptera belonging to the families *Mymaridae*, *Tetragrammidae* and *Trichogrammidae* parasitise eggs of damselflies. Parasitising

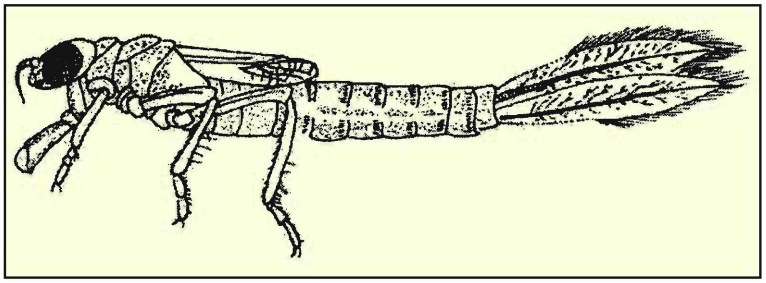


Figure 7. A damselfly larva.

females climb or swim beneath the water to search for the eggs in the submerged plants.

Dragonflies lay their broad and elliptical eggs either in flight or by perching on overhanging vegetation or rock. Eggs are laid in successive batches: a damselfly lays about 100-400 eggs and dragonflies, usually about several hundreds to thousands per batch. In the tropics, eggs usually hatch in 5-40 days. Eggs of temperate species may over-winter and hatch in about 80-230 days. In many stream dwelling dragonflies, the eggs are invested with a gelatinous substance which expands and becomes adhesive on contact with water. This keeps the eggs from being carried away far from the habitat by water currents.

Dragonflies lay their broad and elliptical eggs either in flight or by perching on overhanging vegetation or rock.

Larval Stages

The odonate larvae are sophisticated predators (*Figures* 7 and 8). Their cryptic colouration and keen eyesight makes them dangerous aquatic hunters. Larvae are generally ambush predators, and they wait for their prey to come close before striking. But larvae of some species systematically stalk their prey like birds of prey or as tigers do. When they are in the striking range they

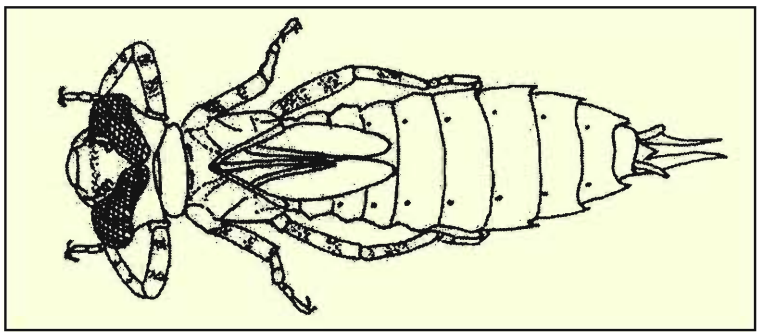


Figure 8. A dragonfly larva.

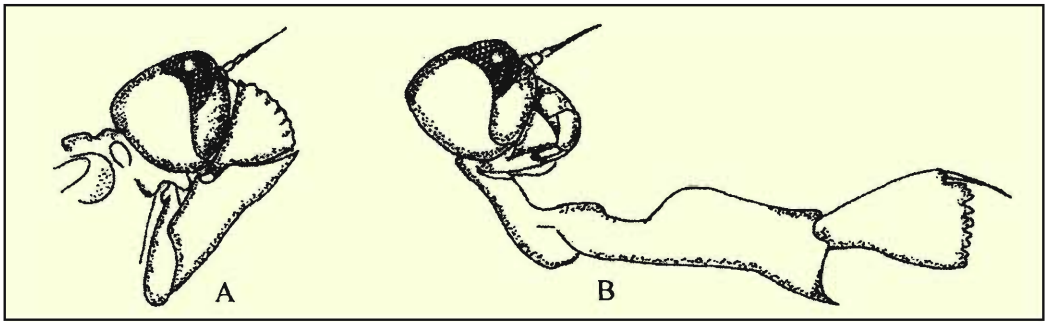


Figure 9. Labium of Odonate larve. A. Retracted, B. Extended.

shoot out their formidable jaws which stab the prey (*Figure* 9). They are gluttonous and feed on any moving and seizable prey including their own kind. Last instar larvae of bigger species are known to even catch small fishes, tadpoles and freshly emerged adults of their own species.

In dragonflies, the inner surface of the rectum has become foliate and richly supplied by trachae. These foliations or 'rectal gills' are the respiratory organs. Pumping movements of abdomen continually renew water in the rectum. In damselflies, there are foliaceous lamellae at the end of abdomen. These are supplementary respiratory devices in addition to the rectum, general body surface and wing sheaths where gaseous exchange also occurs.

A typical odonate larva completes its development in about two months.

A typical odonate larva completes its development in about two months. The number of larval instars is very variable within and between species and is usually between 9-15. When they are ready to moult, the larvae stop feeding and crawl up to emergent vegetation or on to a rock. This usually happens after sunset and the larvae moult into adults just before sunrise. The newly emerged adults are wet and delicate, and as the day warms up, they become dry and robust for their maiden flight.

Adult Stage

Newly emerged males and females leave their emergence site and occupy nearby areas between attaining adult form and reproductive ability, with males generally travelling farther

Odonates surpass all other groups of insects in their flying skills. Odonates have uncoupled wings unlike moths, butterflies, wasps and bees. In other words, the fore and hind wings are unattached to each other and beat independently.

than females. In a few species, the maturation period serves as a resting stage and lasts about 8-9 months. However, most damselflies complete their maturation in about three weeks or less, whereas dragonflies take about two weeks. During the maturation period, sequential changes occur in the colour of the body and wings.

Flight

Odonates surpass all other groups of insects in their flying skills. Odonates have uncoupled wings unlike moths, butterflies, wasps and bees. In other words, the fore and hind wings are unattached to each other and beat independently. The powerful thoracic muscles give odonates the ability for long sustained flight as well as good manoeuverability. Odonates can hover and turn 180° while in flight. Dragonflies are stronger fliers than damselflies, and can reach a speed up to 25-30 km per hour. This difference in flying abilities influences their dispersal and geographic distribution. It is generally observed that big powerful fliers have wider geographic range than smaller species that are relatively weak fliers.

Like many other organisms, dragonflies also migrate. One of our most common species, *Pantala flavescens* migrates immediately after the monsoons. Large swarms of these dragonflies move through prominent clearings in the landscape such as highways and railway tracks. It is not yet clear how and where they migrate.

Many migrating species are intermediate hosts of trematode parasites of birds, such as like *Prosthogonimus*. During mass emergence of these species, aquatic birds such as sandpipers, terns, gulls and herons feed on them. This predation forms an important link in the transfer of Metacercatiae and cysts of the parasite.

The larval stages of water mites (Hydrachnidia) also parasitise odonates. For example, *Arrenurus cupidator* is a common ectoparasite of coenagrionid damselflies. The mite larvae seek the final instar host larvae by random tactile search. The larvae

briefly feed on the host larva and when the adult damselfly emerges, the mite larvae get attached to the adult. Mite larva then pierce the host body and start feeding. The larvae detach only when the host comes back to water for oviposition. The detached larvae complete two more larval stages as predators before moulting into adults.

Feeding

Adult dragonflies are aerial predators and catch small insects like mosquitoes and midges, and even small butterflies, moths and bees on wing. Most of the dragonflies are day flying but a few actively hunt during twilight hours. Dragonflies capture their prey by perching at a vantage-point and making short sallying flights, or by flying continuously. In this, they resemble insectivorous birds like flycatchers and swifts, respectively. Large numbers of adults sometime congregate near tree canopies to feed on swarming insects especially during dawn and dusk. They feed in flight, using the legs to capture the prey and transfer it to the jaws. The legs are highly specialised for this purpose, particularly with regard to their position, relative length, articulation and complement of spines. The vision of dragonflies is well developed and the whole head is more or less made up of the eyes.

Adult dragonflies are aerial predators and catch small insects like mosquitoes and midges, and even small butterflies, moths and bees on wing. They feed in flight, using the legs to capture the prey and transfer it to the jaws.

Reproduction

Sexually mature dragonflies return to the breeding habitat from their foraging or roosting sites. Males usually mature earlier than females and reach the breeding habitat first. Mature males hold territory, but species may or may not show pronounced site fidelity. Resident males show aggressive behaviour towards conspecific males that enter their territory. Aggressive behaviour may be simple 'wing warning' by perched males and a display of abdomen. More elaborate aggressive encounters occur in flight, progressing from mutual threat display to physical fighting.

Odonates are sexually dimorphic. Newly emerged males and females are similarly coloured. Males acquire bright colouration

Figure 10 (left). Mating of Copera vittata: in tandem position.
Figure 11 (right). Mating of Copera vittata in wheel position.

as they become reproductively mature. Colours and patterns in the wings and body may play an important role in territoriality and courtship. Courtship is more evident in damselflies than in dragonflies. It ranges from simple submissive posture by males towards approaching females to elaborate displays where the male flies towards an egg laying site and allows itself to be carried by the water current for a short distance. Competition over sexually receptive females is very intense among male odonates.

A receptive female adopts a characteristic posture towards a potential male and pairing follows immediately. The last abdominal segments of the male have claspers, which are used to hold the female by her thorax. The structure of the female thorax is such that the male clasper fits exactly into it. This 'hardware key' prevents mating between closely related species. The sequence of events, which ensue into copulation, is illustrated (*Figures* 10 and 11). During copulation or just before that, the male transfers his sperms into an accessory genital organ at the second abdominal segment. This accessory genitalia has a complicated harpoon shaped structure, which removes sperms of previously mated males from the female reproductive tract before insemination. Multiple mating in both males and females

is common among odonates.

Egg-laying

Egg-laying commences immediately after copulation. The male either continues to hold the female and flies with her to an egg-laying site, or just accompanies her. It is usually observed that territory holding males accompany females and non-territory holding males maintain physical contact with the female while she is laying eggs. During this period the female is usually very vulnerable to attack by other males. Non-mated males attack the mated pair and try to hijack the female. Some damselflies lay eggs in submerged plants. In such cases the hovering male anchors the egg-laying female (*Figure* 6).

Longevity

Most of the records of longevity in nature refer only to the reproductive period. This period lasts up to 8 weeks in most damselflies and up to 6 weeks in dragonflies. If we include the maturation period, it may extend up to 7-9 and 8-10 weeks, respectively. Dragonflies encounter a large number of predators throughout their life. Fish are important predators of odonates during the larval stage. Birds such as hobby (*Falco subbuteo*), bee-eaters (*Merops sp.*), kingfishers, herons and terns have also been observed to feed on odonates. Large dragonflies, robberflies (Asilidae) and spiders are important invertebrate predators on odonates.

Human Significance

Odonates are an important group of aquatic insects and are among the dominant invertebrate predators in wetland ecosystems. Being predators both at larval and adult stages, they play a significant role in the wetland food chain. Adult odonates feed on mosquitoes, blackflies and other blood-sucking flies and act as an important biocontrol agent for these harmful insects. In the urban areas of Thailand, larva of container breeding dragon-

Odonates are an important group of aquatic insects and are among the dominant invertebrate predators in wetland ecosystems. Being predators both at larval and adult stages, they play a significant role in the wetland food chain.

Suggested Reading

[1] P S Corbet, *A Biology of Dragonflies*, London: Witherby, p.247, 1962.

[2] P S Corbet, Biology of Odonata, *Ann.Rev. Entomology*, Vol. 25, pp.189-217, 1980.

[3] T E Clark, and M J Samways, Dragonflies (Odonata) as indicator of bio-tope quality in the Kruger National Park, South Africa, *Journal of Applied Ecology*, Vol. 33, pp. 1001-1012, 1996.

[4] M Prasad, *Faunal diversity in India: Odonata*, Zoological Survey of India, Calcutta, pp.171-178, 1999.

fly, *Bradinopyga geminata*, have successfully been used to control the *Aedes* mosquito, an important vector of dengue fever. Many species of odonates inhabiting agro-ecosystems play a crucial role in controlling populations of insect pests.

In addition to the role of odonates in ecosystem function, their value as indicators of quality of the biotope is now being increasingly recognised. For example, in South Africa it has been shown how species assemblages of dragonflies change with levels of human disturbance. Dragonflies found at undisturbed habitats with good riparian vegetation tend to be specialists with a narrow distribution. On the other hand, species recorded in industrial land or urban areas with disturbed riparian vegetation are usually generalists with wide habitat preference and distribution. These studies also show that dragonflies are sensitive not only to the quality of the wetland, but also to major landscape changes, especially changes in the riparian zone.

Recent studies on dragonfly ecology in the Western Ghats of India indicate that they could serve as indicators of ecosystem health here too. About 38 percent of the odonates of the Western Ghats are endemic and they have specific habitat preferences. Though the Indian odonate fauna is well known in terms of adult taxonomy, their ecology is little worked out. To design a feasible biomonitoring tool using odonates, two issues need to be addressed immediately. The first is our understanding of ecology of odonates. Larval stages of only 76 of the 500 odd Indian species are known, and the full life history is known only for 15 species. A good understanding of larval ecology is crucial to assess wetland health. This paucity of ecological information is a serious lacuna when designing any biomonitoring tool. The second issue is the effect of landscape changes going on for the last fifty years or so in the Western Ghats on dragonfly distribution and status. This can be tackled only by fresh field surveys to know the threat status and distribution of many species. Future studies on dragonflies may be directed to have a comprehensive understanding of their ecology and their value as a biomonitoring tool.

Address for Correspondence
K A Subramanian
Centre for Ecological Sciences
Indian Institute of Science
Bangalore 560 012, India.
Email:
subbu@ces.iisc.ernet.in