



Giant Hawker (*Tetracanthagyna plagiata*) female, in characteristic aeshnine position with down-hanging abdomen. Photo: Tay Soon Lian.

Ode to Odonata

Text by **Cheong Loong Fah, Tang Hung Bun** and **Robin Ngiam Wen Jiang**

With a new book out soon about dragonflies and damselflies (order Odonata), odonating (i.e. watching dragonflies) is about to take off in Singapore in a big way. Here we provide an introduction to help beginners find their way amongst a conspicuous and fascinating group of animals.

Dragonflies are truly kings of the air. One of the most majestic in appearance is the Giant Hawker *Tetracanthagyna plagiata*. Its wingspan that can go up to a whopping 160mm, which is larger than that of a sunbird. Watching this enormous creature flying about in the swamp forest, it easily feels as if one is transported to a lost world.

Indeed, *T. plagiata* belongs to an ancient noble lineage that has remained

largely unchanged throughout evolutionary time. It belongs to the family Aeshnidae, which is considered to be one of the most archaic indeed, evidenced by the fact that, like damselflies, females possess well-developed ovipositors with which to insert their eggs into plant tissue or soil. Damselflies hark back about 300 million years. It was the time of invertebrate gigantism when the wingspan of the extinct dragonfly order Protodonata exceeded 700mm.

Nowadays, *T. plagiata* vies with a couple of other giants for the honor of being recognized as the world's largest known living dragonfly.

Hawkers (Aeshnidae)

T. plagiata, like many other members of the Aeshnidae family, exhibits a crepuscular lifestyle. However, the evening hours in our forests really belong to those aeshnid species in the genus *Gynacantha*. Like a conjurer's trick, these large, swift-flying hawkers appear from the dark inner space of the forest during this moment of transition between day and night. They create an active kinetic pattern in the dim evening landscape with their tireless and energetic flights, yet they always have a slightly unreal and supernatural appearance. While watching dragonflies by the sun-dappled streams has its charm and romance, beholding these spectral forms appearing at dusk in the silent shade also has a mysterious allure.

In *Gynacantha*, it is probable that the increased size and efficiency of the eyes make possible the swift and often erratic flight. Nevertheless, it is likely that *Gynacantha* escapes the ever present danger of spider webs not by keenness of sight but by sheer bulk and momentum. It is common to find a fully adult *Gynacantha* with bits of spider webs attached to its wings or body, strands which would have proved the undoing of other smaller dragonflies.

Crepuscular flight is probably an adaptation to the food supply, as there is a big burst of small insects flying everywhere at dusk. It could also be that there is reduced predation from birds during the crepuscular hours. The *Gynacantha* species typically cease to fly as soon as the bats begin.

It is very difficult to observe these wildly darting forms when they are in full flight. It is far easier to observe them by flushing them from their diurnal roost. When flushed, they usually fly a short distance and alight on some twig or stem, or in the undergrowth, in characteristic aeshnine position with down-hanging abdomen.

Curious about their specific identification, we have actually caught them by hand. Examining their wings and appendages under a field magnifying glass, we have been rewarded with the discovery of aeshnid species new to Singapore, like *Gynacantha dohrni*, *Heliaeschna crassa*, and *Heliaeschna uninervulata*.

Dragons Of The Air (Gomphidae)

No spectacle of the odonate world is more awesome than the flight of the gomphids, especially the swirling skirmishes of gomphids in their territorial battles. They make incredible twists and turns, seemingly able to make 180 degree turns at full speed in little more than their own body length. They make aeshnids look slow! When gomphids are present, there is always a sense of drama in the scene. As they launch their long slingshot trajectory high into the blue sky, they scorch the air with the power and speed of their flight.

Gomphids are sometimes given the common name of clubtails because quite a number of gomphids have club-



The common aeshnid Lesser Green Emperor (*Anax guttatus*) inserting eggs into submerged reed. Photo: Francis Alvin Lok.



A Dingy Duskhawker (*Gynacantha subinterrupta*) female with its large eyes. Strands of spider webs can be seen attached to the wings and bodies. Photo: Cheong Loong Fah.

tails, like the very common Common Flametail *Ictinogomphus decoratus*. While the club itself would seem to carry an energy cost in long-distance flight, it might act as an excellent counterbalance to enable tight high-speed turns. Some gomphids lack clubs but have rather long abdomens, which might serve the same function of keeping the high-speed turn under control.

Gomphidae is one of the more speciose families, yet the least well known. Many gomphids forage high above the vast unexplored green ocean

of the forest canopy, defying observation. Even those that are not arboreal tend to be extremely wary and are inclined to take evasive action very quickly. The result is that except for a few common species, many gomphids elude even the most experienced odonatologists and avid naturalists. Most are pronounced "rarely seen in the wild".

In Singapore, Ris' Clubtail *Leptogomphus risi* and Malayan Spineleg *Merogomphus femoralis* are recent discoveries. The former is classified as rare and local by Orr

(2005), whereas for the latter, only a single male specimen is known from Malaysia. The two *Burmagomphus* species, Splayed Clubtail *B. divaricatus* and Lesser Splayed Clubtail *B. plagiatus*, are only recorded from Singapore in their larva form; no adults have been seen in the wild.

Looking through many of the Peninsular Malaysia species, we find many gomphid species whose status are also pronounced as rare, such as *Acrogomphus malayanus*, *A. minor*, *Onychogomphus duaricus*, *O. thienemanni*, *O. aemulus*, etc. We suspect that some of these species could be present in Singapore too.

Dragons Beware— Preys And Predators

Some of the best habitats for watching the spectacle of odonate life are at those rainwater-filled low-lying areas like Tuas and Marina East. It is a special moment when one arrives early in the morning hours. The mist blurs the sense of time and place, and all reminders of man are lost. Then the scene changes as the sun rises. As the air is heated up, the dragonflies are stirred into frenzied action. This sense of urgency seems not just a response to the rise in temperature, but a pattern of life characteristic of dwellers of ephemeral habitat. The timelessness of these marshes in the morning mist is

but an illusion; they are ephemeral habitats after all, liable to dry up after the monsoon rains.

Here in these rainwater-filled basins, as elsewhere, one can observe two main modes of dragonfly hunting. The fliers catch and typically consume their prey while flying, while the perchers take off from an observation post, catch their prey and return, often to the same spot, and consume it. Many dragonflies are strong and fast fliers, capable of reaching speeds of up to 50-60 km/h. Their wings have a sophisticated architecture of veins, which ensure that the wings are stable enough to bear such speeds. On the other hand, hidden amidst the lush aquatic vegetation are many delightful Lilliputian damselflies, which are all perchers. While damselflies are slower, they are capable of exquisite wing control that facilitates forward-reverse flight and deft maneuverability.

Except for some specialists, most odonates are opportunistic foragers and have a catholic diet. However, as prey, flies and mosquitoes (dipterans) outnumber all other taxa. The celebrated naturalist W.H. Hudson once described how, on the pampas of Patagonia, the appearance of a foraging dragonfly was welcomed by travelers, because it resulted in the instant departure of the

Some odonates are known to take large prey, even equal to their own body size, the most dramatic being cannibalism.

clouds of mosquitoes and blackflies that had been pestering them. Unfortunately, here in Singapore, the effect of dragonflies is not as dramatic in terminating the flight of the mosquitoes.

Some odonates are known to take large prey, even equal to their own body size, the most dramatic being cannibalism. For instance, the libellulid Variegated Green Skimmer *Orthetrum sabina* and the coenagrionid Ornate Coraltail *Ceragrion cerinorubellum* both exhibit strong tendency for cannibalism. The term is here used in its zoological



Common Flametail (*Ictinogomphus decoratus*) is by far the commonest member of its family. Photo: Cheong Yu Jia.



The locally rare Banded Hooktail (*Paragomphus capricornis*) emerging in the morning hours. Photo: Cheong Loong Fah.



A Blue-throated Bee-eater (*Merops viridis*) with a dragonfly along the Nee Soon pipeline trail. Photo: Morten Strange



A Blue-tailed Bee-eater (*Merops philippinus*) has just captured a Saddlebag Glider (*Tramea transmarina*). Photo: Lee Tiah Khee.



A Pied Fantail (*Rhipidura javanica*) has grabbed a female (*Brachythemis contaminata*). Photo: Wei Luen Chan.



Robber flies in the family Asilidae are also a threat to dragonflies. Here one has captured a *Diplacodes* sp. Photo: Cheong Loong Fah.



Charming Flashwing (*Vestalis amoena*) feeding on a cranefly. Photo: Cheong Loong Fah.



An *Orthetrum sabina* feeding on a *Tyriobapta torrida*. Photo: Cheong Loong Fah.

meaning, referring to a species eating members of its own kind, not always to species level.

Adult odonates themselves form important prey items. Birds that fly as well as or better than dragonflies have dragonflies at a disadvantage, not only in terms of their ability on the wing, but also because they have better eyesight. Examples are the smaller falcons such as the falconets and kestrels, and the dragonfly hunters par excellence, the bee-eaters. The duels between the bee-eaters and the dragonflies are always fascinating to watch, and as the prey and the predator re-enact this perpetual dance between life and death, one cannot help but admire their superb flying skills.

There are also birds that hunt in the marsh vegetation taking adult damselflies, such as bitterns and herons (family Ardeidae). They find the damselflies at a disadvantage because of the slow flight necessary to dodge between the upright sedges, cattails and similar plants.

Migration

During the monsoon months, the open spaces over both our urban and rural areas are invaded by dragonfly migrants like the Wandering Glider *Pantala flavescens*. These migrants fill the air with their effortless gliding motion. They are also known as the “Storm Chasers”, seeking temporary pools created by the heavy monsoon rains and laying their eggs in them. Their ability to spot a rain pool is so acute that any smooth, shiny object can attract their attention. Thus females can often be found absorbed in the futile task of laying eggs on the roof of a parked car. Some evidence suggests that this species may actually hitch a ride with storm systems—even, perhaps, with hurricanes—in order to be perfectly poised to take advantage of fresh breeding habitats.

P. flavescens is the most cosmopolitan dragonfly in the world, found in both hemispheres to about 40 degrees latitude, and on such remote land masses as Hawaii and Easter Island. It is a consummate glider and can glide for a few hours on end. It has been recorded from ships in the middle of the ocean and at 20,000 feet in the Himalayas. Recent radar studies in China have



The sight of the Yellow-Barred Flutterer *Rhyothemis Phyllis*, another Libellulid, with its brown and orange batik colour, gliding over our open woodlands, is emblematic of our countryside. Photo: Cheong Loong Fah.



The Wandering Glider (*Pantala flavescens*) has a broad wing base that is adapted for lengthy gliding rather than strong flight. Photo: Cheong Loong Fah.

detected substantial migratory movements over the ocean at night and at heights of up to 1,000m. Nevertheless, how they achieve this navigational feat is still poorly understood. It is one of those commonplace miracles that keeps alive our sense of wonder and makes us go out to the field time and again!

Whereas bird migrations are true return movements in which an individual migrant completes one or more round trips between breeding and non-breeding areas during its lifetime, dragonfly migrations are thought to be intergenerational movements in which an individual migrant carries out a migration in only one direction, with its offspring making the return trip at a later time.

P. flavescens has a highly accelerated life cycle that allows it to get in and out of ephemeral pools before they dry up. The larvae feeds with exceptional aggression and appetite and can go from egg to adult in a blistering six weeks. The emergence of adults from a rain pool can be a real spectacle, with huge swarms forming, and moving off en masse in search of new breeding sites, which could be on an entirely different continent.

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Colour and polymorphism

With their brilliant iridescent hind wings, the males of Green Metalwing (*Neurobasis chinensis*) are among the most conspicuous and well-known inhabitants of clear forest streams throughout the region. When the insect takes to the air during courtship, the slow hind wing beat produces bright flashes of metallic green to attract the females. The renowned odonatologist M.A. Lieftinck was so impressed by their beauty that he rapturously called them the ‘Birds of Paradise’ among Odonata. Sadly, *N. chinensis* is now probably extinct in Singapore due to habitat destruction. No specimen has gladdened our eyes for almost the last 50 years.



Green Metalwing (*Neurobasis chinensis*) with dorsal green iridescence on hind wings. Photo taken in Endau Rompin. Photo: Cheong Loong Fah.



Common Bluetail (*Ischnura senegalensis*) female andromorph, resembling the male it is mating with. Photo: Tang Hung Bun.



Two male Fiery Gems (*Libellago aurantiaca*) engaged in aerial territorial dispute. Photo: Tang Hung Bun.

Some odonate species occur in several colour forms which are genetically inherited rather than age-related. For example, mature females of Common Bluetail *Ischnura senegalensis*, a common damselfly in open ponds and marshes, are polymorphic. They occur in three colour forms: olive, orange and one form that resembles the male (andromorph), i.e. green on the lower part of the thorax and azure blue on the abdomen segment 8 and the sides of segment 9.

It has been proposed that male-like morphs in female Odonata serve to protect females from being harassed by males. This theory was supported by the fact that female polymorphism occurs more often in species where males search for mates, but less so in families in which males are territorial (whereby females can shun harassment by avoidance). There is still much to be discovered about this topic.

Sexual behaviour and territory

The sexual behaviour of the odonates is one of the most fascinating aspects of their life history. There are various issues of interest, such as whether it is the males or the females who control the mating – in other words, does female choice occur in the odonate world? The complicated mating system of the Odonata also offers many possibilities for mechanical isolation of species, both during tandem and copulation. Thus, it will be worthwhile to first understand the reproduction behaviour of the Odonata.

Most of the dragonflies that one sees around ponds or ditches are adult males. Around the water, adult males of some species establish territories for breeding, and they will drive away intruders by sparring, flight contests and threat displays of bright colours on the abdomen or wings. The territorial defense behaviour of some species is indeed very spectacular to watch.

For example, the beautiful Fiery Gem (*Libellago aurantiaca*) can be seen engaged in aerial territorial disputes, where two males face each other and make forward movements without bodily contact. They hold their nearly motionless forewings forward to display the dark apical spots while their flight is

maintained by the flapping of their hind wings. This can go on for more than half an hour until one of the males flees the territory.

Females typically spend most of their adult life away from the water, foraging in the nearby trees, bushes and grasses. They come to the water only when they are ready to mate.

Tandem Position

When a male encounters a receptive female in the breeding site, he will use the anal appendages to clasp her securely behind her head (dragonflies) or prothorax (damsselflies) to form a tandem pair. This action usually takes less than a second. At this stage, the couple is said to be “in tandem position”. Some species (e.g. damsselflies in the family Calopterygidae) show complex courtship rituals before this stage. Tandem pairs of dragonflies and damsselflies can occasionally be seen flying about, the female behind the male.

Sperm transfer

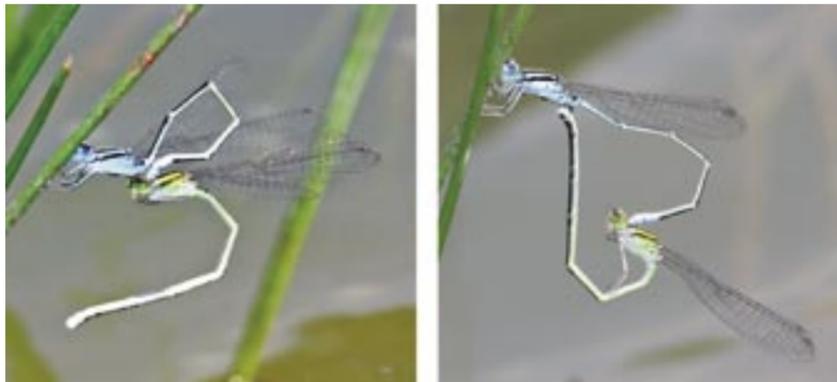
Odonata sex involves a bizarre step, unique among insects. Before a male can mate with a female, he must first “mate” with himself. The male genitalia, where sperm are produced, open under abdominal segment 9, near the tip of the insect’s abdomen. The male insect also has secondary genitalia at segment 2, near the base of the abdomen. The secondary genitalia include a sperm storage reservoir and a penis. Before he can mate with a female, the male has to transfer sperm from the tip of his abdomen into the storage reservoir at the base of his abdomen. The male achieves this by curling his abdomen beneath his body, and touching the aperture of the sperm duct on the 9th segment to the opening of the sperm reservoir at the base of the abdomen. Depending on the species, this takes place either before or after the male has formed a tandem pair with a female.

Copulation - Wheel Position

After the male’s sperm transfer and the couple achieving the tandem position, the female curls her abdomen forward to link the tip with the male’s secondary genitalia in order to receive sperm. The male and female form a heart shape



Shorttail (*Onychargia atrocyana*) in tandem position. The insect in front is the male. Photo: Tang Hung Bun.



Look-alike Sprite (*Pseudagrion australasiae*) in sperm transfer (left) and wheel position (right). Photo: Tang Hung Bun.



Shorttail (*Onychargia atrocyana*) in wheel position. Photo: Tang Hung Bun.



A pair of rare Scarlet Adjutant (*Aethriamanta brevipennis*) in tandem (left) and wheel (right) positions while in flight. Photo: Tang Hung Bun.

wheel and it is known as wheel position. This may take place while the two dragonflies are perched, and last several to many minutes, or in flight and be over in seconds. In some species of damsselflies, during the wheel position, the pair’s slender bodies form a delicate romantic heart shape.

Sperm displacement

A female dragonfly can mate repeatedly with different males. She stores sperm from various matings in a special receptacle within her body near the tip of her abdomen. Fertilization of the eggs takes place only as they are being laid. This offers the opportunity for the next male to displace the sperm stored in the female’s sperm-storage organ delivered to her during her previous mating. Dragonfly males are endowed with multi-purpose penises fashioned with brushes and hooks to physically remove or displace rival sperm from the female reproductive tract. In some dragonflies, the multi-purpose penises can also provide sensory stimulation to the females during copulation to induce ejection of any previous sperm received. Hence, in dragonflies, mating first will not ensure paternity. This explains why some male dragonflies appear to be paranoid about guarding against rival males.

Egg laying

After the completion of copulation, the couple may split up, or they may stay together through oviposition, i.e. egg laying. In some species, the male guards the female from the competition of rival males. In other species the female is left alone to lay her eggs. Guarding may take several forms. The most basic form for damsselflies is contact guarding, where the male stays attached to the female for the entire egg-laying process. Many dragonflies employ hover guarding, in which the male hovers above or perches near the female as she is laying eggs. A hover-guarding male may attempt to protect several of “his” egg-laying females at a time. The oviposition method varies according to species and/or circumstances.

In the family Aeshnidae of dragonflies and in all families of damsselflies, the female is equipped with a curved, blade-like ovipositor with which she



Blue-spotted Flatwing (*Podolestes orientalis*) ovipositing by cutting a slit in a plant stem. Photo: Tang Hung Bun.



Spine-tufted Skimmer (*Orthemtrum chrysis*) ovipositing by dipping her abdominal tip to the water surface. Photo: Tang Hung Bun.

cuts a slit in a plant stem or leaf and inserts a single egg. Egg laying may be above the waterline, at the waterline or even below the waterline — sometimes so deep that the insect plunges below the surface for many minutes, possibly obtaining oxygen from the water via a thin air pocket that is trapped in the fine hairs on its body.

In many Libellulidae species, the female dips her abdominal tip to the water surface and washes off her eggs while hovering or flying, often at high speed. Some species scatter their eggs over the water from the air and some use splash-laying to throw drops of water containing eggs onto plants or the

bank. If the eggs are deposited above the waterline, the newly emerged larvae reaches the water by either falling, or by a series of spasmodic hops caused by arching its whole body and flicking itself into the air. There have been occasions when females oviposit on unsuitable surfaces such as oil slicks and vehicles, mistaking them to be a water surface.

Odonate Conservation in Singapore

In a fast developing Singapore the conservation of our natural heritage is of utmost importance. In particular, the conservation of dragonflies faces a huge challenge, as wetlands and streams are constantly under threat from urbanisation. One example is the recent conversion of the Tuas marsh into a motorcycle circuit. It is poignant to know that the marsh is the only place where the rare Hooked Midget *Mortonagrion falcatum* damsselfly is recorded so far. Thankfully dragonfly conservation in Singapore has also taken a step forward. In our nature reserves the value of stream biodiversity has been realised and is now under appropriate conservation management. Furthermore, the creation and enhancement of ponds in public parks to attract dragonflies has been initiated. Already, ponds harbouring rare species have been

identified for management. The naturalisation of our waterways by PUB's ABC program will surely create more dragonfly habitats, see <http://www.pub.gov.sg/abcwaters/abcwatermasterplan/Pages/default.aspx> for details. In terms of outreach, dragonfly talks and courses have been conducted, and dragonfly storyboards have been produced in some parks. The Nature Society (Singapore)

With enhanced dragonfly appreciation in Singapore, these large and beautiful insects have the potential of becoming a flagship group of species for freshwater conservation in general.

also played a significant role by adopting the Kranji Marsh, thereby preserving a good dragonfly habitat. Plans are also in place by the Society to conduct dragonfly-watching trips for its members.

So what can you do to help conserve Singapore's dragonflies? It is easy. Just go out and enjoy odonating (dragonfly-watching) in the many accessible places such as park ponds and nature reserves. Take pictures of them, observe their behaviour, and share your findings with fellow dragonfly lovers. You can also post dragonfly pictures on websites like Asia Dragonfly (<http://www.asia-dragonfly.net/index.php>). You might even discover a new species or some new aspect of odonate behaviour.

Also, spread the message of no littering and no releasing of unwanted pets in our forest streams and ponds to safeguard the freshwater habitats. One should also be aware of the harmful effect of pesticide usage on the integrity of the aquatic habitats.

Dragonfly-watching is already very popular in places like Japan, Taiwan, US and Europe. With enhanced dragonfly appreciation in Singapore, these large and beautiful insects have the potential of becoming a flagship group of species for freshwater conservation in general. 🌿



This rare *Mortonagrion falcatum* used to live at Tuas Marsh, which has been converted into a motorcycle circuit. Photo: Cheong Loong Fah.



Bishan Park is one of our best parks for dragonflies. 33 species have been recorded so far. Photo: Robin Ngiam.



Toa Payoh Town Park has a very accessible pond for dragonfly watching. Photo: Robin Ngiam.

Editor's note: Odonata is an order of insects that includes dragonflies and damselflies. The word Odonate is an English version of this term. The last published checklist in 2008 contained 117 odonate species recorded from Singapore. Since 2008, more new records have been made, pushing the number of species to 124 currently. An updated checklist will be published in a dragonfly photo identification guidebook by Tang Hung Bun, Wang Luan Keng and Matti Hämäläinen in May this year.

Dr. Cheong Loong Fah started out as a birdwatcher, but now he likes to roam the forest searching for insects, including the dragonflies and the various beetle families. He has written a series of articles, on both birds and insects, in a column provided by the Chinese press.

Tang Hung Bun has always been a nature lover. Inspired by Loong Fah, he started watching dragonflies in 2005. In 2009, he retired early from teaching and now expends his energy on writing a book on the dragonflies of Singapore.

Robin Ngiam chased dragonflies during his childhood kampong days. Those fond memories have developed into a deep passion for them. That passion is deepened further after getting acquainted with the co-authors, who are his dragonfly mentors and friends. He has just completed a two-year dragonfly conservation project in NParks.

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