DRAGONFLIES & DAMSELFLIES

OF NEW ZEALAND

MILEN MARINOV & MIKE ASHBEE

▲ A teneral sentry dragonfly clings to its exuvia while hardening through the night.

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▲ A male yellow spotted dragonfly illustrating the association of this group of insects with flying dragons.

Preface

Dragonflies – if a name should reflect character, then dragonflies could not have been better named. Dragons in legends, mythologies and fairy tales are often pictured as strong, fearsome, merciless rulers of the air, but are sometimes portrayed as full of wisdom. Dragonflies have it all: they are strong, dynamic fliers showing no mercy towards mosquitoes or many other small insects. What about wisdom? Well, one could argue that by surviving the many major extinction events since the first dragonfly-like ancestor appeared on our planet – more than 325 million years ago – this group of insects has indeed earned the label 'wise'. Regardless, today's dragonflies are superbly adapted to their environment.

Damselflies, on the other hand, look completely opposite to their relatives – delicate wings; slim, elongate abdomens; large, wide-set eyes that track the minutiae of the world around them; subtle nuances of colours on their bodies in a combination that is very often pleasing, even entrancing, to a human observer. No wonder that their common name associates them with a young girl.

However, both dragonflies and damselflies have similar life histories and the same general organisation of their bodies. Therefore, they are combined in one insect group – the order Odonata. Since there is not a general common name for the whole group, people often refer to them all as 'odonates'. Likewise, for convenience, that approach is used in this book dedicated to New Zealand species of Odonata.

The New Zealand damselfly and dragonfly fauna comprises 14 species currently known to breed in the North and South Islands, Stewart Island/Rakiura and the Chatham Islands. Additional species have been recorded on the Kermadec Islands and others still have arrived occasionally on New Zealand's main islands but have failed to establish permanent populations. Some tropical Pacific odonates are gradually expanding their ranges with increasing global temperatures and may find their way to New Zealand in the near future. This book includes all those species, but local New Zealand residents are our main focus because most of them are endemic, meaning that they are found only on these four main islands and nowhere else in the world. We pay special attention to what we need to know and do in order to protect them from introduced pest animals and plants, which may deplete or smother dragonfly natural habitats and replace our unique treasures forever.

New Zealand's eight endemic species sit in five genera (spread over four families), three of which – *Xanthocnemis*, *Uropetala* and *Antipodochlora* – are entirely endemic (the other two genera have species found outside of New Zealand). The evidence suggests that some of our endemics developed from ancestors that were isolated from the rest of the world more than 80 million years ago, after the break-up of the supercontinent Gondwana. Subsequent generations persisted, surviving through New Zealand's geomorphological history, which included subsidence of the

▲ Male gossamer damselflies are dainty and extremely pretty insects.

land, earthquakes and volcanic activities, the formation of mountains and glaciation. So, today's odonates are messengers, time capsules containing encoded genetic information from ancient times when their ancestors were flying together with the predecessors of species that we now find on distant continents such as Australia and South America.

Odonates may not possess human intelligence but they can certainly help us to exercise our brains more effectively. Observe and remember what you see, and refer to this guide. You can go one or more steps further by taking notes in the field and/or recording encounters with a camera or sketchbook. There is no better way to connect with nature. The more you watch odonates, the more you will be enchanted. The more carefully you observe them, the richer will be your experience.

In fact, damselflies and dragonflies are easy to observe. The life of adult odonates is enacted in or around the open wetlands, rivers or temporary puddles in which they breed. Almost all you have ever read in nature books or watched in natural history documentaries about the lives of mammals or birds – such as establishing and defending territories, finding mates and food, or the general struggle for existence – is easily observable from the bank of an overgrown pond. Just book your seat by bringing a chair and watch the odonates dance over the water.

Wetland, river, puddle, pond – the link between odonates and freshwater is more than just opportunistic. These insects depend on freshwater, and many species are quite sensitive to its quality, so the cleaner the waterway, the more diverse and abundant is its odonate fauna. Record the presence of adults of each species throughout the year, noting this on a calendar. Keep doing this year after year. Do not stop. You will come to expect each

▼ Damselflies and dragonflies are easy to observe from the bank of a pond.

▲ A female redcoat damselfly greets us at a pond's edge in Christchurch, New Zealand. Odonates are excellent indicators of water quality and they can 'teach' us how to manage our freshwater resources.

species to appear at a particular time of the year and to fly for a specific period. When there are changes in your local water habitats, damselflies and dragonflies will be among the first to 'tell' you – you'll notice fewer species, lower numbers than usual or even different species. These alarm bells can prompt you to check with your neighbours to find out what may have happened and how it can be fixed.

This book aims to be a broad guide to New Zealand Odonata. Use it: as an identification manual; as a source of information on damselfly and dragonfly biology; for instructions on how to take close-up photos of insects in nature; for directions on where to observe odonates; for ideas for future studies; for guidelines on conservation activities; and as an album of nature photos. For quick reference in the field, you can use the separate identification chart in this book. We like to think that we are giving you a guide to last your lifetime. At least, that's how we feel about these insects, which have guided our lives for more than 30 years. For us, odonates have been a never-ending source of joy, wonder and intellectual stimulus. We hope we have managed to convey the pleasure that we have experienced during years of study and that you, the reader, will enjoy your time with New Zealand damselflies and dragonflies as much as we have!

Natural History

This book includes those odonates so far established on New Zealand's four main islands as permanent or accidental residents. To date, 14 species are recognised as breeding in the North and South Islands, Stewart Island/Rakiura and the Chatham Islands. There are 11 genera, which are in turn grouped into six families.

Eight of these species are endemic – *Austrolestes colensonis*, *Xanthocnemis tuanuii*, *X. zealandica*, *Uropetala carovei*, *U. chiltoni*, *Antipodochlora braueri*, '*Procordulia*' *grayi* and *P. smithii*. Four species (*Ischnura aurora*, *Anax papuensis*, *Hemicordulia australiae* and *Tramea loewii*) established breeding populations in New Zealand less than a hundred years ago. The remaining two (*Aeshna brevistyla* and *Diplacodes bipunctata*) are also found on other Pacific islands and in Australia; however, preliminary studies indicate that the New Zealand species have unique features that distinguish them to some extent from their overseas counterparts.

To make sense of New Zealand's odonates, we begin with a broad look at what these insects are and where they fit in the global classification of organisms living on our planet.

DAMSELFLIES AND DRAGONFLIES IN THE NATURAL WORLD

The branch of science called taxonomy deals with the naming and classification of living organisms. Scientists working in this field are taxonomists. They place organisms into hierarchically ranked groups or taxa (singular 'taxon'). At the lowest level, similar individuals that are capable of interbreeding and producing fertile offspring are categorised as being of the same species. Closely

Suborder	Family	Genus	Species	Species common name
Zygoptera	Lestidae	*Austrolestes*	*colensonis*	Blue damselfly
	Coenagrionidae	*Ischnura* *Xanthocnemis* *Xanthocnemis*	*aurora* *tuanuii* *zealandica*	Gossamer damselfly Chatham redcoat damselfly Redcoat damselfly
Anisoptera	Petaluridae	*Uropetala* *Uropetala*	*carovei* *chiltoni*	Bush giant dragonfly Mountain giant dragonfly
	Aeshnidae	*Aeshna* *Anax*	*brevistyla* *papuensis*	Lancer dragonfly Baron dragonfly
	Corduliidae	*Antipodochlora* *Hemicordulia* *'Procordulia'* *Procordulia*	*braueri* *australiae* *grayi* *smithii*	Dusk dragonfly Sentry dragonfly Yellow spotted dragonfly Ranger dragonfly
	Libellulidae	*Diplacodes* *Tramea*	*bipunctata* *loewii*	Red percher dragonfly Common glider dragonfly

Kingdom **Animalia**
Phylum **Arthropoda**
Class **Insecta**
Order **Odonata**
Suborder **Zygoptera**
Family **Coenagrionidae**
Genus ***Xanthocnemis***
Species ***zealandica***

▲ Taxonomic classification of the redcoat damselfly (showing main taxonomic categories only).

related species of common evolutionary origin that cannot interbreed form a genus. Similar genera are combined in a family, and the hierarchy continues as increasingly inclusive groups: order, class, phylum, kingdom and domain.

Since 1758, scientific names follow the binomial ('two-name') system of nomenclature devised by the Swedish naturalist Carolus Linnaeus. Every species is identified uniquely by its genus followed by its species name, as well as the name of the scientist who described the species and the year that description was published. The need for this is easy to see. There are, for example, many species named *chiltoni*, honouring the distinguished New Zealand zoologist Charles Chilton. These include worms, a fish, a snail, a crab and several insects. But the dragonfly *Uropetala chiltoni* Tillyard, 1921 is uniquely identified as a dragonfly of the family Petaluridae by its associated genus, as well as the fact that the description was published by the Australian entomologist Robert John Tillyard in 1921. The author and date are needed to establish priority in case another author should later publish the same name referring to a different species. If new information comes to hand and the species is later moved to another genus, the original author's name and date are placed in parentheses. Although all scientific names are nominally in Latin, they are frequently based on Latinised classical Greek or other languages (as in the *chiltoni* example, which is based on an English name).

Another advantage of an organism's scientific name being a unique combination of genus plus species is that it provides worldwide consistency, which is especially important for communication between scientists. Although common names may be easy to use, they can often cause confusion even among the native users. The term 'sandflies' illustrates this well. The annoying midges that New Zealanders call 'sandflies' are 'black flies' if you live in Britain or North America, but they all belong to the same family, Simuliidae. On the other hand, in Australia, 'sandflies' is the common name for equally annoying insects of a different family, Ceratopogonidae.

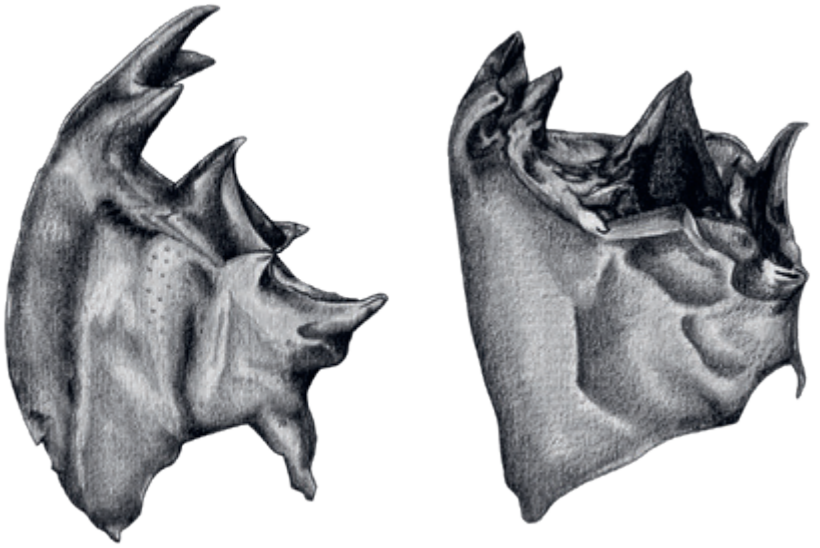
It bears pointing out, however, that non-scientific names have often been used to successfully distinguish between closely related species. Members of a tribe in Papua New Guinea recognise 137 out of the currently known 138 species of birds found in their area. The only two species they did not differentiate were very closely related.

Similar-looking species pose problems even for 21st-century taxonomists. Historically, species were classified using only morphological traits and they remain very important for identification and in describing new species. However, where morphological features are ambiguous, scientists use additional features based on the specimens' geographic distribution, behaviour and ecology. In recent years, taxonomists also compare the molecular structure of sections of the specimens' DNA. This has proved especially valuable in revealing higher-level relationships between groups, such as where a family should be placed, but it can also reveal 'cryptic' species – species that are almost impossible to differentiate by their outward appearance.

Turning specifically to the taxonomy of odonates, they belong to the kingdom Animalia, phylum Arthropoda, class Insecta. Collectively, insects represent the most successful lineage of multicellular organisms on the planet, both in numbers of individuals and diversity (numbers of species). In fact, the number of insect species greatly surpasses that of all other animal, plant and fungi species combined.

Insects are grouped into more than 30 orders. This book deals with just one, the order Odonata. The name of the order means 'toothed' and originates from the powerful serrated jaws (or 'mandibles') that are typical of all members of the group. Although Odonata is a comparatively small order of the Insecta (with just over 6000 extant species), the group has a very long evolutionary history. The oldest fossil record of a dragonfly dates back more than 250 million years and odonates' giant relatives – the Griffenflies – date back 325 million years. Unfortunately, no fossil odonates have been found in

▼ A pair of mandibles of the ranger dragonfly, showing the teeth from dorsal (left) and ventral (right) views. BORIS MARINOV



◀ Fossil of *Tupus gallicus* from the Middle Permian (265 million years ago), from France. ANDRÉ NEL

New Zealand yet. This is a significant gap in our knowledge as fossils would tell us much about our past fauna and provide clues to understanding the present-day distribution of our species.

All New Zealand Odonata are divided into two suborders: Zygoptera and Anisoptera, which correspond to the common names 'damselflies' and 'dragonflies'. All our Zygoptera are small and light in build, and they rest with their wings folded together above the body, whereas our Anisoptera are larger, more heavily built and rest with their wings open. The two suborders differ in several other ways. In Zygoptera, the fore- and hindwings are almost identical, narrow and often stalked; Anisoptera have dissimilar wings that are broad at the base, especially the hindwing. They also differ in the terminal appendages of the male and in their naiads (this term, sometimes called a larva or nymph, refers to the period of life between egg and adult). Zygoptera naiads have slender and nearly parallel-sided bodies with three long, paddle-like gills (also known as 'lamellae' because of their thin, flat and often transparent layer). Anisoptera naiads are stouter, with laterally expanded abdomens, and they lack lamellae. Instead, their internal gills line the walls of the rectum, which can be sealed by closing small, spine-like projections on their abdomen.

Although Odonata comprises both damselflies and dragonflies, in recent years, 'odonates' or 'dragonflies' have been used widely when referring to all members of the order. In this book, whenever we speak of odonates, we mean the entire order Odonata. In some specific instances, we refer to the two suborders by their scientific names: Zygoptera and Anisoptera.

HABITATS OF NEW ZEALAND DAMSELFLIES AND DRAGONFLIES

New Zealand has a unique odonate fauna. Given the size of the two largest islands and the availability of good damselfly and dragonfly habitat (sites with poor drainage that can accumulate freshwater), New Zealand has surprisingly few species, all of which occur at relatively low abundance. In other parts of the world with a similar climate, most freshwater habitats sustain rich odonate communities, although there are progressively fewer species as one approaches the poles.

▲ Adult and naiad Odonata are very convenient subjects for studying general insect body morphology. Clockwise from top left: Adult blue damselfly; Naiad of the blue damselfly; Adult yellow spotted dragonfly; Naiad of the yellow spotted dragonfly.

Running and standing waters each provide a host of distinct habitats, supporting unique communities of naiads preferring different freshwater conditions. In the Northern Hemisphere, some species are especially adapted to live only in very harsh conditions, such as occur in bogs within the Arctic Circle where temperatures are very cold even during the summer, or in fast-running, shaded mountain streams passing through cool temperate forests. By contrast, New Zealand rivers and streams are almost devoid of odonates, a phenomenon that has never been fully explained. The geological and climatological history of the land undoubtedly had a significant impact on the evolution of local damselflies and dragonflies and the composition of the present fauna. The islands that form New Zealand today are the elevated remnants of a now mostly submerged continent, Zealandia. This large block of continental crust extends from the Subantarctic Islands to New Caledonia. About 84 million years ago, Zealandia began to separate from the Australian portion of the supercontinent Gondwana. Apart from Zealandia, Gondwana included what are now Australia, Antarctica, India, Africa, South America and some larger islands such as Sri Lanka and Madagascar.

With the break-up of Gondwana, its odonate fauna became fragmented and isolated on the separating land masses. We do not have fossil evidence to judge what share of species New Zealand received from the probably rich

Gondwanan fauna. We can, however, assume that during the millennia of isolation, New Zealand's species were exposed to dramatic geological and climatic events. New Zealand travelled further south, taking warm-adapted species to a colder climatic zone. During the subsequent tens of millions of years, Zealandia's surface area was reduced to a few islands owing to the subsidence of a large part of the land. Most probably glaciation also took its toll, reducing further an already impoverished odonate fauna. The southern latitudes may have been more favourable for cold-tolerant insects such as stoneflies (order Plecoptera) and some mayflies (order Ephemeroptera), which develop predominantly in mountain streams. However, damselflies and dragonflies that occupy such habitats are mainly restricted to the tropics. Odonates found in temperate-zone mountains typically inhabit lakes and ponds.

In New Zealand, volcanic and tectonic activity raised some of the low-lying lakes (several of the present-day tarns), isolating the species in and around them from their lowland counterparts. Streams and rivers that originated on the newly raised slopes offered a wealth of new habitats. However, the species specialised to life in standing water probably were unable to occupy their unclaimed niches. It has been suggested that some populations of redcoat damselflies in the North Island may have invaded streams in shady forested areas and, over time, the descendants acquired morphological features which more than a hundred years ago were considered sufficient for them to be described as a separate species. Similarly, redcoat damselflies in the mountain tarns of the South Island are probably gradually

▲ Waihihi Stream by Puriri Grove Track, Hunua Ranges. MILEN MARINOV

▼ Mountain tarn in the Canterbury high country.

differentiating from populations in the rest of the country. Unfortunately, with the lack of any fossils of dragonflies or dragonfly-like organisms, and no detailed comparisons between New Zealand species and those from the rest of the world, every theory is speculative at this stage. An integrated study involving several scientific disciplines is needed before we can begin to explain the paucity of odonates throughout New Zealand, especially in running water and in the South Island.

In fact, in running water habitats of the South Island, there are scarcely any species at all. The dusk dragonfly is the only New Zealand species with an affinity for flowing water and its distribution is limited to shady forest streams in the North Island. The redcoat damselfly may survive in slow-flowing rivers of the South Island, especially in areas where the water backs into small eddies along vegetated banks. Naiads

▲ Sandy Creek, Waiparere Farm, Wairoa, Hawke's Bay region.

of the ranger dragonfly have been found occasionally in running water in the South Island, but usually close to larger still-water basins from which they had most probably been flushed. That species also survives in North Island streams, but prefers sunnier sections than the dusk dragonfly and the redcoat damselfly. Unfortunately, our beautiful braided rivers do not support any viable odonate populations, as their ever-changing shape and rocky bottoms are not suitable for any of our present species.

Although both the redcoat damselfly and the ranger dragonfly can breed in running water, they are clearly far more abundant at ponds, lakes and other standing-water habitats. These species can even be found in lakes with slightly increased salinity, such as Brooklands Lagoon near Spencer Park, north of Christchurch. Coastal wetlands are also occupied by the blue damselfly and the red percher dragonfly, which may colonise very shallow and temporary pools, ponds and ditches. Freshwater lakes near the coast are good areas to find lancer and baron dragonflies. The freshwater allows the growth of a dense fringe of emergent vegetation and also supports floating plants, both of which provide perches for dragonflies and sites for egg-laying and emergence. Like the blue damselfly and the red percher dragonfly, the lancer dragonfly can breed in very shallow water.

Inland lakes (such as Rotoaira and Rotopounamu, near Taupo) with large areas of open surface water are attractive sites, especially for the yellow spotted dragonfly. The naiads live among submerged aquatic plants or on the lake bottom. Bank vegetation is also important to them for successful emergence. However, naiads do not depend on this entirely as adults

▲ Brooklands Lagoon in Spencer Park, near Christchurch.

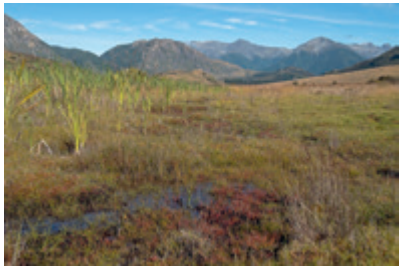
▼ Lake Rotopounamu, near Taupo.

sometimes emerge directly on rocks or fallen tree trunks near a bank. The yellow spotted dragonfly is also a common species in city gardens and at pools in recreational parks such as Otipua Wetlands, south of Timaru, and The Groynes Recreation Reserve, near Christchurch.

Some North Island ponds are dominated by the sentry dragonfly, which is gradually occupying larger territories in the South Island. Currently known as far south as Christchurch, this species may soon be recorded further south, especially with the present global trend of increasing annual temperatures. However, given its preference for warm habitats (adults have been observed patrolling over thermal streams near Rotorua, which were quite hot to touch), it is unlikely that the sentry dragonfly will ever establish at high elevations in South Island mountain tarns and peaty lakes. These areas are usually occupied by the redcoat damselfly, the blue damselfly and the ranger dragonfly.

▲ The Groynes Recreation Reserve, near Christchurch.

▼ Boggy area above Lake Sarah, near Cass.



▲ Burrow entrance of a bush giant dragonfly, Tanekaha Tracks, Brynderwyn Range, Mangawhai. Diameter of ring is about 2 cm.
MILEN MARINOV

Areas of open tussock grasslands with tiny water trickles flowing downhill are the habitat of the mountain giant dragonfly. Giant dragonflies are exceptional in that their naiads live in burrows dug into wet soils, usually densely overgrown with mosses and often far from any surface water. The size of the burrow depends on the naiad's stage of development, but they can be as deep as 70 cm. They may end in blind chambers or be U-shaped, thereby providing an alternate exit to escape a potential threat. The burrows are always partially inundated but are usually dry at the entrance, although in particularly wet soils the water level may reach almost to the burrow's opening. The naiads always keep the burrow clean – doing 'home maintenance' each night. Growing roots are nipped off, and collapsed soil is removed to a small pile at the entrance using the broad, flat mouthparts as shovels. Vacated burrows very soon became obliterated by growing roots and collapsing soil.

Adults of the mountain giant dragonfly are often encountered on some of New Zealand's more common alpine walks. Similarly, the bush giant dragonfly is also seen along walking tracks that pass through forested areas. Adults of this species tend to avoid open areas and prefer the shade of the trees. They may fly across forested clearings, but are rarely seen perching on completely exposed, sunlit vegetation.

Clearly, New Zealand odonates have survived the many cataclysms over time that have shaped their natural habitats. Some species are continuing to adapt to today's constantly changing environmental conditions – changes wrought mostly through human modification of habitats and introduction (unwitting or deliberate) of exotic species. Understanding the species' needs for natural space is crucial in our attempt to preserve the unique assemblage of New Zealand damselflies and dragonflies that we have inherited.

ENDEMICS AND MORE RECENT ARRIVALS

Nowadays, with so much interest in odonates, species new to science are being discovered regularly and well-known species are turning up in the most unusual places. The aptly named wandering glider or globe skimmer (*Pantala flavescens*) has been found in the Himalayas at altitudes above 6000 m a.s.l. The same species is the only known dragonfly from Easter Island and it is also reported as regularly appearing in huge numbers over the Maldives. The latter entirely lack open freshwater, making it impossible for any dragonfly species to breed and establish a permanent colony there. The species' nearest known breeding habitat is in India and some researchers believe the Maldives are just a staging post in a more than 3000 km migration from India to the east coast of Africa.

Scientists are still searching for plausible explanations for this and similar discoveries. An often-cited hypothesis is wind-assisted flight across the ocean. Some studies even suggest that certain species of Odonata evolved wings that enable them to glide, which would make journeys between oceanic islands energetically possible. These conclusions are supported by some curious observations, such as the astonishing migration of the green

► Wandering glider (*Pantala flavescens*).

▲ Green darner (*Anax junius*).

darner (*Anax junius*). Using various methods, including attaching micro-radio transmitters to the insects, scientists tracked a journey of nearly 3000 km across the North American continent. It seems probable that if odonates can migrate such long distances, they could also travel successfully from eastern Australia to New Zealand, a mere 2000 km approximately.

Indeed, some odonate species must have accomplished this in the past given the species composition of contemporary New Zealand and that of our neighbours. Nowadays, the New Zealand fauna comprises almost equal numbers of endemic species and those with a wide distribution in Australia and various Pacific islands. However, at the beginning of the 20th century, the fauna of our four main islands consisted of endemic genera, endemic species and just two Australian species (which possibly may have been distinct subspecies). Other Australasian or Indo-Australian species reached New Zealand less than a hundred years ago. The gossamer damselfly – which is very often cited as an example of a wind-borne insect, passively carried on air currents and transported to new territories – was first recorded here in the mid-1920s. The baron dragonfly, otherwise known from Australia, Indonesia, New Guinea, New Caledonia, Norfolk Island and the Kermadec Islands, was first captured in New Zealand in 1918. The sentry dragonfly, native to Australia and also found in the lesser Sundas, Norfolk Island and the Kermadec Islands, was originally reported as an occasional immigrant to New Zealand in the 1920s. The common glider dragonfly, found in Australia, Timor, New Guinea and New Caledonia, established breeding colonies on the northern part of the North Island around 2005–7.

The establishment of these four widespread species in the last hundred years raises an interesting question: Why did it not happen earlier? Well, perhaps it did and warm-adapted species had been arriving from the tropics regularly, but found the New Zealand environment too harsh and quickly died out. On the other hand, perhaps they arrived and survived for a time but were not noticed by the scientific community. Around the turn of the 20th centuries, there were only a few local entomologists monitoring the whole country, so some of the species mentioned above may have arrived even earlier than recorded. We owe our knowledge of the arrival of baron and sentry dragonflies and the gossamer damselfly to the medical practitioner (and entomologist) John Armstrong, who collected intensively mainly around Lake Taupo. Dr Armstrong presented good evidence for the rapid spread of the newcomers, which were already quite well established around the lake by the 1940s and 1950s. He also commented that a local species (the yellow spotted dragonfly) might be replaced by an invader (the sentry dragonfly).

An even more important question is: Did the new species arrive using their ability to fly long distances or was their introduction due to human influence? The above-mentioned migration of the wandering glider from India (to the Maldives and then) to Africa is still a hypothesis, which has not yet been proven. The green darner, on the other hand, does migrate long distances; however, the dragonflies are always flying over land or have it at a distance as visual stimuli. Since green darners have stored fats for only a maximum of 8.3 hours of flight, they must stop regularly to feed while flying over the land. Obviously, this isn't possible while flying over large expanses of open water, so long ocean crossings would surely require wind assistance. Furthermore, it can't be conventional oceanic winds that carry insects between oceanic islands because such winds weaken close to the shore. Instead, violent storms are proposed as the most likely agent to translocate insects between islands. Researchers from Bernice Pauahi Bishop Museum in Honolulu surveying the transoceanic movement of insects on board ships in the mid-20th century argued that the physical conditions of the insects caught within the storm were not necessarily fatal and often some of them were still active even when tossed on the ship by the wind. After a 10-year study in the open ocean, the Museum scientists inferred that insects' own, natural power of dispersal had been overestimated. Their conclusion was that, at the time, humankind was the primary agent transporting insects from one location to another.

This brings us back to the four dragonfly species that were recorded as 'new' in New Zealand in the last hundred years. It is quite possible that humans played a key role in their establishment here. The time of first arrival of those species coincides with the return of the ANZAC troopships after World War I, which mostly docked in Australia before their final journey to New Zealand. We cannot say for certain if ships brought back any alien

▼ A sentry dragonfly.

insects, but the possibility cannot be ruled out. What we do know is that dragonflies often travel aboard large vessels cruising the oceans. Night-time illumination of ships attracts many insects, including dragonflies and especially those hardy, widespread species that can be found near ports and towns.

New Zealand's most prominent Odonata researcher Dr Richard Rowe considers two additional, human-related factors to be increasingly significant in facilitating the colonisation of new locations by dragonflies: global warming and habitat modification. The northward movement of dragonflies associated with rising temperatures has been well documented in Europe, with new species records almost a yearly occurrence in Fennoscandia (the large peninsula comprising the Scandinavian Peninsula, Finland, Karelia and the Kola Peninsula (part of Russia)), and elsewhere. New Zealand has been less affected than most places, but slight rises in temperature over the last 20 years may have tipped the balance, allowing species such as the common glider dragonfly to establish breeding populations. Deforestation and farming activities have probably created many new habitats for opportunistic breeders to settle in New Zealand. The newly arrived species are known to be relatively unfussy about where they lay their eggs and where the naiads develop, although they do favour open and often disturbed habitats.

Therefore, should (when?) tropical and/or subtropical species somehow find their way to New Zealand's main islands, the continuing increase in annual temperatures and expanding agricultural sector will mean conditions are more favourable for them to settle. Already the globe skimmer has reached the North Island as an occasional vagrant but has so far failed to establish breeding populations. There are several other widespread tropical species that could very well reach the Kermadecs or even the North Island in the near future. They are all beautiful insects, and no doubt would be an attractive addition to the depauperate New Zealand Odonata fauna. However, according to recent ecological studies, they are likely to compete with locally established species. These potential new arrivals are presented on pages 144–47.

BIOLOGY AND BEHAVIOUR

Body structure

Dragonflies are members of the huge phylum Arthropoda, which includes all other insects, the commonly seen myriapods (millipedes and centipedes), arachnids (including spiders and mites) and crustaceans (including crabs, lobsters, shrimps and barnacles). Arthropods are invertebrate (lacking a backbone) animals, with a segmented body. They have one distinctive feature – an exoskeleton (external skeleton) with jointed legs, from which the name of the phylum is derived. 'Arthropod' is Greek for 'jointed foot'.

Among insects, there is an astounding diversity of body types, which all have arisen from a basic hexapod (six-legged) body plan over evolutionary time. Text books, websites and other resources use various schemes to demonstrate the general body structure of an insect, with the most commonly used examples being grasshoppers, wasps and flies. However, all of them have drawbacks when presented as the archetypal insect body plan. For example, when observing grasshoppers in the field, you will find some disproportionally enlarged body parts that may obscure other less obvious features and their wings may completely cover the abdomen or, conversely, be reduced or missing altogether. On the other hand, wasps and flies have certain body parts fused or underdeveloped. These examples make it challenging indeed for an observer to assess all of the features of an insect's body plan.

The large size and well-defined structure of damselflies and dragonflies makes it relatively easy to see their main body parts with the naked eye. In addition, odonates are generally highly conspicuous in their environment, either perching prominently or staying on the wing for long periods. Furthermore, they often have colourful bodies, which can be easily differentiated into the main parts typical of all insects: head, thorax and abdomen. Understanding this basic structure is a good starting point from which to appreciate the various distinguishing features of odonates detailed in the Species Accounts in this book.

▲ Examples of New Zealand species of non-insect Arthropoda. Top to bottom: Green orbweb spider (*Colaranea viriditas*); Freshwater crayfish (*Paranephrops planifrons*); Common millipede (*Eumastigonus* sp.).

▼ The body parts of an odonate: head, thorax and abdomen.

Blue damselfly

Austrolestes colensonis (White, 1846)

endemic

Mature male.

ADULT IDENTIFICATION
This is New Zealand's only blue odonate, and the largest of the Zygoptera species found here. Mature males are normally blue with metallic black markings. Young males and females may appear predominantly greenish due to the iridescent sheen given off from the dark areas of the body. The sexes are also easily distinguished by their body shape: females are stouter compared with males, which also have long thin appendages at the tip of the abdomen.

MEASUREMENTS
males **tbl** 43–45 mm, **hw** 24–25 mm;
females **tbl** 40–41 mm, **hw** 25–27 mm

GENERAL BEHAVIOUR
The long, thin naiads are most common in the shallow waters of ponds, pools and lakes. Underwater, they are constantly in motion and do not appear to be territorial. Naiads usually emerge on bank vegetation but many lose their grip, fall into the water and need another attempt before they emerge. Immature adults disperse quickly from the water, often flying kilometres away. They feed very actively (cannibalism is quite common) because they do not store much fat as naiads. Their colouration changes with the temperature: on cold mornings, both sexes are dull in colour, but with rising temperatures, their colouring lightens and, in males, the blue becomes more vivid. Females that are sufficiently warmed may also look bluish. Mature males set up territories along the rushes and sedges. Intruders are chased away by swift, aggressive attack flights.

BREEDING HABIT AND HABITATS
Breeding pairs show a strong preference for rushes and sedges. Breeding can occur in minute trickles and tiny pockets of marginally permanent water, usually at sunlit sites. Males seize passing females without any courtship display, and copulation takes place mainly in the early afternoon. The copulatory wheel lasts about 10 minutes, during which time the couple perches on vegetation. Females oviposit predominantly in rushes, selecting stems deep within a cluster, and insert the eggs into the plant tissues above water level. The male typically guards the female by holding her in tandem during oviposition. The newly hatched pronaiad wriggles down the stem following the track left by the female while ovipositing. If it falls on dry ground, the pronaiad 'flicks' its body in little jumps until it reaches water.

WHERE TO OBSERVE IN NEW ZEALAND
Very common all over the country. It is one of the dominant species in mountain tarns and is thought, therefore, to be adapted to colder environments. The blue damselfly is also present on Stewart Island/Rakiura and Chatham Island (Rēkohu).

▼ Mature female.

▲ Immature female.

▲ Naiad.

▲ Naiad raising its caudal lamellae in a threat display.

FLYING PERIOD

It has been observed year-round throughout the country. It is unclear if records of late-flying individuals from June and July are of overwintering adults. The best period to see adults is from the beginning of November to late April.

FUTURE STUDIES

Studies have shown that the Chatham Island population differs at a molecular level from the populations on New Zealand's main islands. For the moment, these differences are not considered sufficient to separate them into two distinct species, especially as no consistent morphological differences have been found.

▼ Male guarding a female during oviposition.

◀ Male cleaning its body.

▲ Adult female blue damselfly from Chatham Island (Rēkohu) with a notable interrupted blue stripe on the thorax. This is a common feature for most of the individuals on the island. DAVID BOYLE

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Superb flyers with extraordinary vision and startling colours, dragonflies and damselflies are exquisite examples of evolutionary adaptation and a favourite of nature lovers around the world. This book is a beautifully illustrated natural history and field guide to New Zealand's 14 species of dragonflies and damselflies.

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