AGRION

NEWSLETTER OF THE WORLDWIDE DRAGONFLY ASSOCIATION

PATRON: Professor Edward O. Wilson FRS, FRSE

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AGRION is the Worldwide Dragonfly Association's (WDA's) newsletter, normally published twice a year, in January and July. Occasionally a Special Issue is produced, as is the case for this issue, that has been published in response to the Covid-19 pandemic. The WDA aims to advance public education and awareness by the promotion of the study and conservation of dragonflies (Odonata) and their natural habitats in all parts of the world. *AGRION* covers all aspects of WDA's activities; it communicates facts and knowledge related to the study and conservation of dragonflies and is a forum for news and information exchange for members. *AGRION* is freely available for downloading from the WDA website at [https://worlddragonfly.org/about/agrion/]. WDA is a Registered Charity (Not-for-Profit Organization), Charity No. 1066039/0. A 'pdf' of the WDA's Constitution and byelaws can be found at its website link at [https://worlddragonfly.org/about/].

Editor's notes

Keith Wilson [kdpwilson@gmail.com]

AGRION Special Issue
Coronovirus pandemic 2019 (Covid-19 or SARS-CoV-2)

In response to the movement restrictions imposed on the vast majority of us throughout the World in early 2020, as a consequence of the Covid-19 pandemic, Vincent Kalkman suggested in late March 2020 that it might be a good idea to produce a special 'Coronovirus' edition of *Agrion*. Due to global restrictions on movement many of us have had to cancel our plans involving any travel over March and April 2020 and from as early as late January in Wuhan and many other parts of China. Apart from essential workers most of us have been more or less confined to home during this period. Jessica Ware, our WDA President was happy to support a special issue of *Agrion* so we reached out to regular contributors to see if a such an issue could be prepared by the end of April. Given the very positive response we received we decided to go ahead and publish this Covid-19 Special Issue of *Agrion*. The issue includes artcles from every continent, except Antartica, reflecting the global reach of the Covid-19 pandemic.

WDA Membership - Important Notice

Control of the membership signing up and renewal process is now being handled by WDA directly from the WDA website. For membership renewal also see the letter sent to all members 16th December 2019. There are several kinds of WDA membership available, either single or family, with or without the WDA's journal (*The International Journal of Odonatology*) in electronic form or hard copy. There are also reduced membership categories for students (grade school, undergraduate, graduate, etc.) and anyone (student or not) residing in a developing nation. You can sign up for a membership using the WDA's website [https://worlddragonfly.org/membership-account/membership-levels/] or by contacting the WDA secretary directly [wda.secretary@gmail.com]. Sponsored memberships are also available for those who cannot afford the cost due to currency restrictions or other reasons.

Conference & Meeting News

The International Congress of Odonatology ICO2021

The next ICO will be held in Paphos, Cyprus at the Neapolis University from 21st to 25th June 2021 and will be organised by The Cyprus Dragonfly Society and Terra Cypria. For further information consult the WDA website [Link] or contact David Sparrow, Chair of the Organising Committee [davidrospfo@hotmail.com].

Cover: The rare *Libellago corbeti* van der Poorten, 2009, which is endemic to Sri Lanka. Photo credit: Risto Toivonen.

Seventh DragonflySouthAsia Meeting

The 7th DragonflySouthAsia Meeting is now going to be a virtual meeting and has been renamed DragonflySouthAsia Virtual Meeting 2020. DragonflySouthAsia, of DiversityIndia, in association with South Asian Council of Odonatology and Society for Odonate Studies is organising a series of lectures on Odonatology that can be viewed on the DragonflySouthAsia Facebook Group. For latest news see Link.

European Congress on Odonatology (ECOO) 2020

The 6th European Congress on damselflies and dragonflies, ECOO 2020, was scheduled to be held in Kamnik, Slovenia from 29 June to 2 July, 2020 with a post congress field trip. The conference organisers announced on April 21st that they: 'have carefully assessed the global situation and after due consideration regarding the health and safety of the participants have jointly agreed to postpone the 6th European Congress on Odonatology'. The Slovene Dragonfly Society now proposes to organize the 6th ECOO at the end of June 2022 for a similar period at the same location. Visit the ECOO 2020 website for more information and consult the ECOO2016 homepage web site for latest annoucements at [https://ecoo2016.wordpress.com/].

Dragonfly Society of the Americas: 2020 Annual Gathering

Scheduled to be held at Lawton, Oklahoma from June 19-21, 2020. Pre-meeting field trips June 16-18 and post-meeting field trips June 22-24 (field trip sites will be in and around the Wichita Mountains Wildlife Refuge, not far from Lawton, OK). As of 28 April 2020 no announcements in respect of Covid-19 had been posted on the DSA web site. For latest news and information see [https://www.dragonflysocietyamericas.org/2020-meeting].

Sociedad(e) de Odonatología Latinoamericana (SOL) 3rd annual meeting, 7-9 October 2020

The Sociedad(e) de Odonatología Latinoamericana is scheduled to hold its 3rd annual meeting in Cusco, Peru from 7-9 October 2020. There will be a post conference trip at the Manu Learning Centre, Peru from 10-13 October 2020. The conference venue is the Universidad San Antonio Abad de Cusco. Details of fees and submission deadlines are soon to be released via the SOL Facebook [facebook.com/OdonataSol] and the SOL website [http://www.odonatasol.org/].

WDA's International Journal of Odonatology

The first issue of IJO in 2020 has been distruibuted and is a special issue focusing on Odonate Flight featuring 14 articles. The issue is now available online at [https://www.tandfonline.com/toc/tijo20/current]. As a WDA member you can access all issues (current and old) of IJO through our WDA members' portal.

Next issue of *AGRION*

For the next issue of *AGRION,* to be published at the beginning of July 2020, please send your contributions to Keith Wilson [kdpwilson@gmail.com] or Graham Reels [gtreels@gmail.com]. All articles, information and news items related to dragonflies or of interest to WDA members are most welcome and will be considered for publication. Please send all text and figure captions in a Word file by email. Please do not include artwork with the text but provide a separate file or files, ideally in a compressed format (e.g. 'tiff', 'jpeg' or 'gif'). Do not make up plates of multiple photos but send original photo images as separate files.

If you have an odonate photo illustrating any rarely observed aspect of dragonfly biology, or an unusual species, or simply a stunning dragonfly shot, please submit it for consideration for publication on the front cover of *AGRION*.

AGRION CONTENTS

Maurits Lieftinck was my guru

Henri J. Dumont [Henri.Dumont@ugent.be]
Gent, Belgium

How does one become an odonatologist? I suppose there exist many ways, with chance playing a major role. In my case it helped to have a guru at the right time, beside being born and growing up in a river valley (the Dender) with plenty of water in a village with an important railway station (Denderleeuw). Until the 1950s, steam engine trains were being assembled and maintained here on a daily basis. Around the end of World War II, my grandfather regularly took me on walks in the swampy woods, where I was struck by some blue needles flying around the vegetation. Somehow this left a deep impression on a four-year old, and I never forgot about it. All my grandfather could tell me was that they were dragonflies (in fact, damselflies). It took me about ten years to find out that their scientific name was *Coenagrion puella*.

Why were they so numerous in my valley? Indirectly because of the local railway station. The German troops routinely sent and sometimes parked ammunition trains there, including V2 rocket transports. The trains and the bridges over the Dender were therefore heavily bombarded by the RAF, but the bombing was sloppy and left deep scars in the valley, sometimes kilometers away from the station. After the war, many of these bomb craters rapidly disappeared, but a good number filled up with water and with aquatic biota. The village youths went there to swim and collect sticklebacks and salamanders. So did I. One day in June I made a fantastic discovery in the water plants: a big dragonfly (eventually I would find out it was called *Aeshna cyanea*) hung from a branch as it was emerging from its exuviae. Excited, I watched the process and would see several more in the next days. This was my first contact with the life history of dragonflies and the closest I had ever been to the ecology of these animals. I was a teenager at the time, mildly interested in biology in a broad sense but ignorant of relevant popular or other scientific literature. I frankly had no idea where to search either. Fortunately, a neighbor, Louis Fobert, who had studied chemistry at Gent University, had a side interest in natural history. He had a few drawers with insects of diverse orders, some identified, others unidentified. The dragonflies were mostly unidentified! But he gave me some guidance and explained, among other things, the system of zoological nomenclature. I studied high school Latin and Greek, mandatory at that time to be admitted at university, and so I found it easy to understand Linnaean names. Thus, I was familiar with the basics of binomial nomenclature and systematics before I had ever heard of Darwin. And then, with 4-5 boys of the neighborhood, I founded a biology club. It eventually produced only one biologist, me, but for a couple of years, the club became an active group of collectors of biological items, insects, bird nests and eggs, and even fossils. In those days, such practices were still normal. We set up exhibitions of our holdings, the first of which was in my father's garage, and tried to bring out a club journal. It was stenciled in about twenty copies (all lost now), and it taught me how to handle a quire and correctly assemble a 24 page publication.

The people of my village visited our exhibitions in numbers, and that provided us with enough money to buy books, a small typewriter, and fund some field trips, allowing us to get an idea of biological environments different from the swamps of our valley. The press got to hear of us, and we were interviewed and even made it to national TV. But we were also growing up. We started dispersing in different directions. In 1956, I finished my village school and moved to the Athenaeum of Brussels. Soon, I discovered that there was a big natural history museum in the capital, and it had a department of entomology.

I still struggled with the identification of most of my dragonflies (and beetles and butterflies as well) and decided to visit the museum, to find out whether they had identified collections that could help me to name my animals as well. I found they could do better than that! I met Dr Georges Demoulin, an ephemerologist from Liege, the closest specialist to dragonflies they had. He agreed to look at my animals, and he came up with a slim volume by one Erich Schmidt, jokingly complaining that I made him suffer (his German was hardly better than mine). The Schmidt fauna of central Europe showed me the first good figures of odonates, and Demoulin explained to me how dichotomous keys work. He also told me about the Belgian entomological society, founded in the 19th century by the Baron Michel Edmond de Selys Longchamps, widely known as the father of odonatology. His enormous dragonfly collection was kept in the museum, and I could visit it if I liked. This came as a shock: this man, almost single-handedly, had built a system for the entire group of odonates, and had described hundreds of species from all over the world. But, for some reason, his works contained almost no figures, and there was also a dearth of good identification works, even for Europe. Schmidt (1929) was excellent, but limited to Central Europe. After I taught myself enough German to be able to use Schmidt, another book, Odonata d'Italia (Conci and Nielsen, 1956) came out. So, I taught myself enough Italian to read that one as well. The differences between the two faunas were enough to convince me of the importance of biogeography. And what about ecology? A couple of years later, I discovered and bought a book by one Philip Corbet and still use it today!

When Selys Longchamps died in 1900, he had no successor. He had tried to groom several candidates, including from Britain and Germany, but nobody managed to fill the gap. As a result there would be no dragonfly

work to speak of in Belgium for more than half a century. Currently, dragonflies have become almost as popular as butterflies, and the Flemish dragonfly club, for example, has around a hundred members. It is a pleasure for me to attend their meetings! But in the late 1950s, when I started as a village boy, I worked in an intellectual desert.

Selys was a highly organized man. No wonder he kept a detailed diary that was recently rediscovered and published in two massive volumes (Caulier-Mathy & Haesenne-Peremans, 2008). For an analysis of his life and times, and the significance of his work, the reader may also consult Wasscher & Dumont (2013).

Around 1957, at the suggestion of Dr Demoulin, I wrote a letter (in French), to Erich Schmidt in Bonn, asking him a number of questions about European dragonflies. I had started a personal research project, of which more below. It would determine my destiny, and I thought Erich Schmidt was the person to call upon for help. After a few weeks, I received a postcard from him in return. It was not very nice. He told me that he could not afford the time to reply to beginners' requests such as mine. He made an exception because of Dr Demoulins' recommendation, and indeed provided short and dry answers to most of my questions (I do not even remember what they were), but it was clear that dragonfly ecology was not his cup to tea. Oddly, the next time he visited to Brussels museum and the Selys Longchanps collection, he gave Dr Demoulin a set of reprints from his own papers for me. They were the first reprints I ever received! I still have them. Erich Schmidt was a strange and paradoxical personality, as others later confirmed to me. I regret I never met him in person.

In the Brussels Athenaeum I had one hour of biology per week. My teacher, Mr Coosemans, managed to fill a whole year with the study of photosynthesis and was not really seeding enthusiasm for his subject into his pupils. But, having heard of my biology club, he took me apart and told me about a yearly prize awarded by the zoo of Antwerp (the Jacques Kets Prize) for an original research work by a final year high-school student. Would I be interested and if so, what subject did I propose? A study of the fossils on top of an Ieperian clay layer in the valley of the Dender? An inventory of the butterflies and beetles? No, I would invest the next two years to learn more about the natural history of the dragonflies, these fascinating insects that spend their larval existence in water, and their adult life in the air. I tried to read about their natural history, and began to set up simple experiments in aquaria. I also spent more and more time in the field, surveying the ponds and bomb craters for their dragonfly fauna, and I identified the species using Schmidt. I came to about 17 species. And I marvelled at seeing an *Aeshna* larva throw out its mask to capture a chironomid. These were the decisive events that made me decide to become a biologist. Up to that time I had wondered whether to become a linguist or a scientist. Having studied Latin and Greek I had a strong basis in language, and I found I could pick up more languages relatively easily. For fun, I tried to teach myself Russian (with moderate success), and later in life I would try my hand at Portuguese, Turkish and Mandarin.

I won the Kets Prize for 1959, and it came with a nice amount of money. With that, I could buy not only more books, but also my first microscope. *Dragonflies in the surroundings of Denderleeuw* contains some incredibly naïve prose, but also some precursors to real scientific observations. I allowed myself to mature (Dumont, 1971) and published the updated essence thereof in a paper about a decade later. By that time the species list had grown to 29 species, and currently it has reached 36 species (Van Schandevijl, 2007). The Denderleeuw marshes and bomb pits, currently known as the *Wellemeersen*, has thereby acquired a regional importance, housing more than half of the Belgian fauna of dragonflies.

As to my future, in September 1959, I enrolled in Gent University. I had long hesitated whether to become a linguist or a biologist, but the Kets award finally tipped the balance in favor of biology. I finished up the standard curriculum in September 1964, earning a degree called licentiate (in zoology), more or less equivalent to a masters. In those days, French was still the dominant language in Belgium, and there was a tendency to ignore terminologies used in The Netherlands, where licentiate was an unknown word. But we found it funny that the French term *licencié* has a double meaning. It denotes as well a license holder as a person that gets fired from his job.

The degree, of course, involved a thesis with public defense, on which I worked in 1963-1964. When I went to see my professor, Lucien De Coninck, I had planned a study of the genetics of color change in *Ischnura*. That was a subject that my student Benny Hinnekint would later take up again because I could not even finish my first sentence. No future in that, my promotor said, do dragonflies as a hobby! And please follow me! He drove me to a place called Lake Donk, some 20 km from Gent. A hydrobiological station had existed there forty years earlier. My professor then gave me my subject. It was very concise: have a look at the plankton of this lake.

That is how I became a limnologist. I found out what zooplankton was and began to study its taxonomy and ecology. In 1964, I was offered a scholarship to continue my plankton work for a Ph. D., which I rounded off in November 1968 (Dumont, 1968). I followed the orders of my promotor, and studied dragonflies as a hobby.

In 1965, I finally met Lieftinck, a name from the literature for me until that time. He came to Antwerp to give a talk for the local entomological society. I do not remember how I had become aware of that, but I drove up to Antwerp to hear him talk, not expecting too much from it. I met a tall, grey haired, distinguished gentleman, slightly ageing. His talk was not about the dragonflies of Asia, a subject on which he had published many, many papers, but a comparison between the dragonfly faunas of Belgium and the Netherlands. Not a very exciting

subject at first sight, but Lieftinck gave a brilliant speech, making the subject sound like a thriller. It ended with a draw: both countries had 65 species, but that might change in the future, he added.

After the talk, I could speak with him. He commented positively on my very first and rather simple dragonfly papers, one on a mass migration of *Libellula quadrimaculata* that I had been fortunate enough to observe during a stay at the marine biology station at Wimereux, Northern France in 1964. The other was youth work. It described the emergence of some dragonfly larvae and was a part of my Kets Prize work (Dumont 1964a, b).

I was charmed by Lieftinck and even more when, about one week later, I received in the mail two big parcels with countless reprints of his papers, including several old ones that had become difficult to find.

We would henceforth remain in contact, meeting from time to time, and in 1969, we joined up in a full day field excursion. The practical side had been arranged by the omnipresent Bostjan Kiauta. Our objective was to find *Coenagrion armatum* at the Naardermeer. Lake Naarder is a huge wetland, situated between Amsterdam and Hilversum. Lieftinck had discovered the species here in the 1920s, and observed it several years in a row (Lieftinck, 1924). He then moved to Indonesia, and nobody had paid attention to the population of *armatum* since. I was intrigued because this peculiar coenagrionid had never been seen in Belgium. One morning in May 1969, our party assembled at the entrance of the nature reserve. It consisted of Maurits Lieftinck, Dirk Geyskes, Janny Van Brink, Bostjan Kiauta, Piet Leentvaar, my wife Simonne, and me. At the time, I was doing my military service, meaning I had needed a special permit to leave Belgium. The permit specified only one thing: I had to travel in civilian clothing.

Figure 1. (A) Naardermeer May 1969. Getting ready to get into the nature reserve. In the boat Janny Van Brink, Dirk Geyskes (at the oars) and Maurits Lieftinck (smoking). (B) Naardermeer May 1969. In conversation, from left to right: Maurits Lieftinck, Janny Van Brink, Henri Dumont and wife Simonne.

Lake Naarder is not a real lake but a network of canals, swamps, and expanses of shallow open water. Our starting point was a small rowboat-port near a windmill, where we boarded two rowboats. We followed Lieftinck's instructions and stopped at places where he had seen *Coenagrion armatum* about half a century earlier

(Lieftinck, 1924). It was a warm sunny day, and there were swarms of coenagrionids on the wing, including thousands of *Coenagrion pulchellum,* but no matter how hard we searched,we found no *C. armatum*! Our failure was not nice, but no drama either. We found ourselves a nice spot to have a picnic and engaged in lively discussions about dragonflies. I had brought a bottle of Beaujolais, which we emptied *in situ*, and Lieftinck clearly enjoyed a good glass. He was also a rather heavy smoker (me too, unfortunately) and so I discovered that he knew how to enjoy life! And *C. armatum* I would later observe in numbers during trips to Siberia, the Urals and Kamchatka peninsula with Anatolyi Haritonov from Novosibirsk.

A message I took home from the trip was that the Wurm glaciation was still felt in the geographic distribution of species, and that glacial relicts that still survived in the Netherlands no longer occurred in Belgium, only a hundred kilometers or so further south.

In late 1971 Bostjan Kiauta twisted my arm to convene the First European Meeting of dragonfly workers at Gent University. Here, we would found the international society of dragonfly workers (SIO) and its journal Odonatologica. I had become a university staff member, and my boss, Professor De Coninck now accepted my work with dragonflies. Bostjan Kiauta became the work horse of Journal and Society. The meeting itself (some 30 people) was relaxed and quite pleasant. Dirk Geyskes, probably Lieftinck's best friend, spoke about the dragonflies of Surinam, while Lieftinck spoke about the tropics. In private, he told me that our knowledge of the odonates of the eastern Mediterranean basin was deeply insufficient while this was the area where the transition to the oriental region was to be found. I had just come back from a field trip in Morocco, largely in his footsteps, and now would turn east, to Yugoslavia and Turkey.

Figure 2. (A) ***Macromia*** **hunting in Cabrerets (France). On camping communal, Simonne and Henri Dumont and Mrs. Bilek Photo credit: Alois Bilek. (B) Maurits Lieftinck giving his paper at the European Dragonfly workers meeting in Gent, September 1971.**

Reading Lieftinck (1965) on Morocco had the immediate effect that I would drive there, in my Renault 4, with wife, son and tent in spring 1971. I found that April was too soon, but returned in July-August with a group of students and came home with a rich harvest (Dumont, 1972).

But even before that, Lieftinck (1966) had attracted my attention to one peculiar corduliid dragonfly, the single west-palaearctic representative of a large tropical genus, viz. *Macromia splendens.* With the reprint of Lieftinck's paper in my hand, I drove to the Lot region in SW France. It was end of June 1969, and I was still in the army. I took out another travel permit and a week of holidays. The Dumont family boarded the Renault 4 once more, and took off. We reached the village of Cabrerets on Célé where a municipal campsite near the river Célé became our late-June temporary home.

The first day I spotted and captured a female along a road away from water, the first specimen I ever laid eyes on. But in the next days the weather turned rainy and no dragonflies were on the wing. Then, we noticed we were not alone in the campsite. Each late afternoon, a VW beetle with an elderly couple aboard came to spend the night. They left during the day, each time reforming the interior of their car from a sleeping room to a regular car. The license plates said Austria and jokingly, I told my wife: this must be Bilek. Next I saw the man searching the trees bordering the river, and I was stunned. Could my wild guess be true? I walked to the little grey-haired man and asked him in French what he was doing. He replied in German, stating that he was looking for "ganz bestimmte Insekten…", at which point I interrupted him and said "oh, you mean *Macromia*". His turn to be stunned! I introduced myself and indeed he was Alois Bilek, and the couple had been there for a week, and captured a beautiful series of *Macromia* (Bilek, 1969). We spent the rest of the week together and had a pleasant time, in spite of the rain and my wife not feeling well, especially in the mornings (it later turned out that our daughter was underway, she was born in January 1970). Bilek (a lab technician in the Museum of Vienna, originally a musician and violin builder) I would never see again, but Lieftinck I would keep meeting from time to time and I am happy to acknowledge his influence on my work. To this day I am profoundly grateful to this "grand monsieur" for having shown me the way to conduct my "hobby". He never earned an academic degree, but was given a doctorate honoris causa by Basel University. I never dared calling him by his first name, but always addressed him as doctor, respectfully! He truly was the reincarnation of Selys Longchamps.

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Finding dragonflies in Singapore's nature parks

Marcus Ng [thebudak@gmail.com]

At time of writing (3 April 2020), Singapore had just announced a de facto 'lockdown' (the Prime Minister dubbed it a 'circuit breaker') for all non-essential services and economic activities. This was an attempt to halt escalating Covid-19 infection rates by imposing effective social distancing measures.[1] The saving grace, though, was that exercising in neighbourhood parks (along with purchasing food and other necessities) was among the few activities explicitly permitted, probably because such nature areas are typically devoid of crowds[2] – a stark contrast to the rest of the island (Singapore has one of the densest populations of any territory, with more than 7,700 people per square km).[3]

For oders such as myself (I don't qualify as an odonatologist), this was a relief, to be able to still seek out wilder corners of the island (if one defines 'neighbourhood park' to include a nearby forest) that harbour many of Singapore's native dragonflies. It may surprise many, including a fair number of locals, but this island (at 725.7 sq km, smaller than New York City and less than half the area of Greater London[4]) is home to 124 extant odonates (133 including locally extinct species), despite its highly urbanised state.[5]

Some of these dragonflies are near ubiquitous. Even in the heart of the city, swarms of *Pantala flavescens* are common. *Rhyothemis phyllis* forms aggregations in housing estates, floating over fields that may teem with *Diplacodes trivialis*. In the many urban parks that dot the city and suburbs, small ponds and artificial marshlands attract tolerant libellulids such as *Neurothemis fluctuans*, *Orthetrum sabina*, *Orthetrum testaceum*, *Brachydiplax chalybea*, *Crocothemis servilia* and *Brachythemis contaminata*, as well as *Pseudagrion microcephalum*, *Ceriagrion cerinorubellum* and *Ischnura senegalensis*. Come dusk, *Tholymis tillarga* can be seen flitting over concrete-lined canals and storm drains, the males' wings a pale whirr above the grey.

The lion's share of Singapore's odonate diversity, however, is confined to nature reserves and nature parks, which account for just about five percent of the island's area but contain most of its surviving forests and wildlife. Much of this is secondary rainforest, which took over gambier plantations abandoned in the late 19th century. But these woods, and the wetlands within them, serve as valuable refugia for those dragonflies – by my reckoning about two-thirds of Singapore's species – that require dense canopies, clear streams and unpolluted swamps. The most well-known pocket of primary forest, Bukit Timah Nature Reserve, has hilly streams with miniature cascades, where

Figure 1. (A) *Devadatta argyoides*, Wallace Trail, Dairy Farm Nature Park. The wings are held open for a few seconds after landing, making it resemble *Podolestes* in poor light. Selys described this drab damselfly (aptly known as the Malayan grisette) in 1859 as *Tetraneura argyoides* using a specimen collected by Wallace in Singapore. Photo credit: Marcus Ng. (B) *Leptogomphus risi*, Wallace Trail, Dairy Farm Nature Park. A female basking by the trail on a sunny morning. Photo credit: Phil Benstead.

1 PM Lee: the COVID-19 situation in Singapore (3 April 2020) [Link].

2 A helpful app charts the visitorship to parks for the purposes of social distancing: [Link].

3 Dip in population density, but not in crowded feeling [Link].

4 Singapore environment data [Link].

5 Soh, M., M. Ng & R.W.J. Ngiam, 2019 New Singapore record of a dragonfly, *Indothemis carnatica,* with an updated Singapore Odonata checklist. *Singapore Biodiversity Records* 2019: 10-17.[Link].

Devadatta argyoides and *Drepanosticta quadrata* may be found clinging to the shadows. Bukit Timah is by far the most well-known nature reserve, but it is also the most visited, so much so that it had to be closed from 2014-2016 to give its trampled and eroded trails a reprieve from daily floods of hikers.[6] Another block of primary growth can be found at Nee Soon Swamp Forest (established as Chan Chu Kang Forest Reserve in the late 19th century), but this wetland, though protected as part of the Central Catchment Nature Reserve, is out of bounds to the public.[7 & 8]

For oders, there are far more rewarding spots, in the form of nature parks at the margins of the nature reserves. These parks were established as buffers that protect the core forests – Bukit Timah and the adjacent Central Catchment Nature Reserve – from disturbance and development. They also provide alternative sites for outdoor recreation and nature observation, with trails and boardwalks from which wildlife, including odonates, can be spotted. At the northern lee of Bukit Timah Hill is Dairy Farm Nature Park, a patch of mature secondary forest on the grounds of a colonial cow farm. This park's visitor centre and main trail are named after Alfred Russel Wallace, who arrived in 1854 and hunted in this part of the island, where he collected the types of *Dysphaea dimidiata*, *Libellago stigmatizans*, *Coeliccia octogesima* and *Brachygonia oculata* (the first two sadly locally extirpated). *Cratilla metallica* are often seen along Wallace Trail, both sexes holding fort on low branches from which they sally for passing prey.

Other libellulids known from this park include *Agrionoptera insignis*, *Orthetrum chrysis* and the locally rare *Lyriothemis cleis*[9], which breeds in water-filled tree holes or buttress pans, microhabitats associated with good quality forests. Another phytotelmata specialist is the giant coenagrionid *Pericnemis stictica*,[10] which also uses rain-filled bamboo stumps, clumps of which are in abundance here. The streams in the park harbour forest species such as *Devadatta argyoides*, *Vestalis amethystina* and the locally rare *Leptogomphus risi*, all of which may bask by trails on sunny days.

On the other, eastern, side of the Central Catchment Nature Reserve is Windsor Nature Park (named after a nearby housing estate), where a network of streams runs through former rubber estates and rural settlements that the jungle retook in the mid-20th century. A large pond near the park entrance presents an easy tally of many open country species (e.g. *Trithemis aurora*, *Aethriamanta gracilis*, *Acisoma panorpoides*, *Ictinogomphus decoratus*, *Anax guttatus*), but

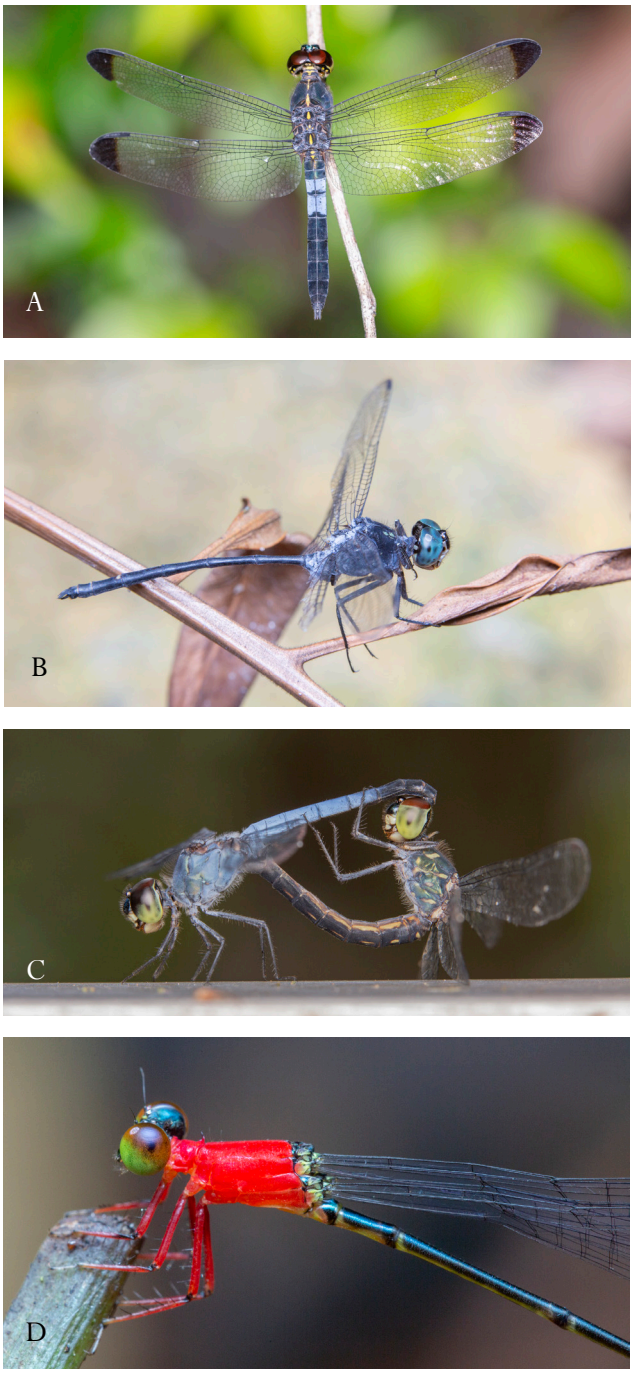

Figure 2. (A) *Cratilla metallica*, Wallace Trail, Dairy Farm Nature Park. (B) *Pornothemis starrei*, Admiralty Park. (C) *Raphismia bispina*, Admiralty Park. (D) *Amphicnemis gracilis*, Windsor Nature Park. Young female, showing the species' characteristic 'hook' on the prothorax. Photo credits: Marcus Ng.

6 Bukit Timah Nature Reserve Reopens after Completion of Restoration Works. [Link].

7 Turner, L.M, C.M. Boo, Y.K. Wong, P.T. Chew & A. Ibrahim, 1963. Freshwater Swamp Forest in Singapore, with particular reference to that found around the Nee Soon Firing Ranges. *The Gardens' bulletin, Singapore.* 48(4): 129-157. [Link].

8 Tropical Marine Institute, 2016. *A guide to the freshwater fauna of Nee Sooon Swamp Forest.* National University of Singapore [Link].

9 Ng, M., 2019. The bombardier dragonfly, *Lyriothemis cleis*, at Dairy Farm Nature Park. *Singapore Biodiversity Records* 2019: 43 [Link].

10 Ngiam, R.W.J. & T.M. Leong, 2012. Larvae of the phytotelm-breeding damselfly *Pericnemis sticta* Selys from forests in Singapore (Odonata: Zygoptera: Coenagrionidae). *Nature in Singapore* [Link].

also some less common finds (at least locally). *Rhyothemis obsolescens* and *Rhyothemis triangularis* lie low in the reedbeds but may ascend to obelisk at more prominent stalks at high noon. *Aethrimanta brevipennis* guard perches by the water's edge from mid-morning, but vanish soon after lunchtime. The giant libellulid *Camacinia gigantea* also makes fairly regular appearances, patrolling the perimeter in the company of smaller fliers such as *Hydrobasileus croceus* and *Pseudothemis jorina*.

Further in Windsor Nature Park are streams with rich riparian growth and wooded edges. On bright days, *Orthetrum luzonicum*, *Orthetrum chrysis* and *Trithemis festiva* fight over the more exposed stretches of these waterways. Closer to the water, as if they occupy a lower aerial stratum from the anisopterans, are mature males of *Archibasis viola*, *Prodasineura humeralis* and *Prodasineura notostigma*. The younger males and females tend to lurk in the trailside vegetation, which also shelter species such as *Onychargia atrocyana*, *Coeliccia octogesima* and *Gynacantha* duskhawkers; the latter seek out dark nooks in the forest by day but emerge in numbers at sundown to feast on the night's first flight of flies.

Tyriobapta torrida (Treehuggers in local parlance) are particularly abundant on certain trailside trees but are not above using passing limbs as ersatz trunks. Males defend swampy pools in shady forest, at times engaging in displays in which the somewhat iridescent hindwings are held still, the better to intimidate a rival. After copulation, females perform frantic vertical loops as they flick their eggs, with a dash of water, at muddy banks.[11] The treehuggers share their breeding habitat with *Podolestes orientalis*, *Agrionoptera sexlineata*, *Nesoxenia lineata*, *Amphicnemis gracilis* and *Teinobasis ruficollis*, all species that prefer the confines of closed swamps and dense canopies.

Figure 3. (A) *Podolestes orientalis*, Windsor Nature Park. Female, apparently ovipositing on a dead leaf by a forest pool. Typically, they oviposit on small branches overhanging water. (B) *Gynacantha dohrni*, Windsor Nature Park. Photo credits: Marcus Ng.

Away from the forested core of the interior, coastal parks and reserves offer sightings of odonates associated with mangrove habitats. At Admiralty Park (named for a former naval base nearby), a boardwalk weaves through a tidal swamp, where crabs and mudskippers dart about muddy flats in the company of *Pornothemis starrei*, *Raphismia bispina* and *Mortonagrion arthuri*, the latter mere needles in a haystack of aerial mangrove roots. Sungei Buloh Wetland Reserve, more famous for its migratory shorebirds and estuarine megafauna such as crocodiles and monitor lizards, has a blend of coastal and open country species such as *Urothemis signata*, *Macrodiplax cora* and *Lathrecista asiatica*. The mangrove-lined paths also serve as passages for *Epophthalmia vittigera* which tirelessly sweep down these natural arbours and back until a long cloud forces them unto a bare twig.

Elsewhere on the island, other nature parks and nature areas with ode-friendly waters, such as Thomson Nature Park, Kranji Marshes and Pasir Ris Park, afford respite from the concrete jungle for both odonates and oders.[12] Even the Singapore Botanic Gardens is a haven for dragonflies: the ponds and recreated freshwater swamplands in this UNESCO World Heritage Site abound with common species but also support scarcer ones such as *Camacinia gigantea*, *Pseudothemis jorina* and *Onychargia atrocyana*. Most of these nature parks are easily reached via public transport (bus, metro or taxi) and none charge entry fees. For those who turn to nature in such periods of stress or distress, the hunt for dragons (and other wild things) comes as a reprieve, a chance to briefly forget and fly in thought, from hours when noses must keep to the ground and nerves are frayed by news fake and fast. The value of odonates and the habitats that support them seems all the more clear in a climate that reveals the power of nature to help and heal, and the peril of wrecking what supports all life, including our own, on this planet.

11 Tang, H.B, 2011. *Tyriobapta torrida* ovipositing [Link] & *Graceful Flight* [Link].

12 *Nature Park Network.* Singapore National Parks Board [Link].

Borneo diaries

G.T. Reels [gtreels@gmail.com]

In these worrying days of lockdown, social distancing and self-isolating we have the small consolation of being able to turn to tasks long-planned but long-deferred. In my case, this has involved putting together my journal of dragonfly-hunting trips to Sarawak, Borneo. From 2004 to 2016 I made 12 such trips, joining my good friend Rory Dow in his ongoing study of the Odonata of that remarkable place. The results of those dragonfly surveys have been variously reported over the years, including several articles in *Agrion*, but these reports have necessarily focused almost exclusively on the Odonata. There is so much else to Sarawak, however - its fascinating ethnic diversity and glorious wildlife - and I tried to record what I could of this in my travel diaries, recounting the daily events of each trip. These diaries I have now compiled into a single account, *Dragons of Borneo*, available as a downloadable PDF on my blog site [https://atratothemis.com]. Here, I present brief non-odonatological extracts from this account, dating from March 2006, December 2007 and July 2016, plus a handful of non-odonatological photographs, which hopefully exemplify the incidental bonuses of dragonfly-hunting activities in interesting places. An unusual *Agrion* article for these most unusual of times.

Long Aton,Tinjar River near Mt Dulit, March 2006

25 March - '…We were ushered into Chief Joseph's house, which lies between the longhouse and the river, and sat down for tea. We were given rooms upstairs. The generator came on around 1800h and we were able to sit down for dinner of pork, vegetables and newly-harvested rice (Joseph almost catching me out by saying grace when I was on the verge of diving into the grub). Rory and I were told (by Luke) that, as the first westerners to visit Long Aton in well over 20 years, we had to finish all the rice. There was a lot of it.

We finally struggled up from the table and crossed in the dark and rain to the longhouse, where we were given a very warm reception. We sat on the verandah which runs the length of the longhouse, and gradually it seemed as if the entire population were sitting on the floor at a discreet distance nearby. Joseph's three venerable sisters made their appearances, one by one coming up to shake our hands. They each had elongated ear lobes (reaching to the shoulder) with round ear rings (Fig. 2A), and all of them had tattooed hands and forearms. Two of them had tattooed feet. I asked how old they had been when these badges of rank were conferred on them, and was told that they had been 15 or 16. The tattoos must have been painful – it took four days to do one hand and arm. They all looked to be in their 60s or 70s now.

Several of the older men were very interesting – still sporting the traditional basin haircut with the long narrow pigtail behind. A bow-legged old chap came up to shake hands, exclaiming delightedly that we were the first white men he'd ever seen (Luke translating). Another lovely old fellow got up to perform a beautiful warrior dance.

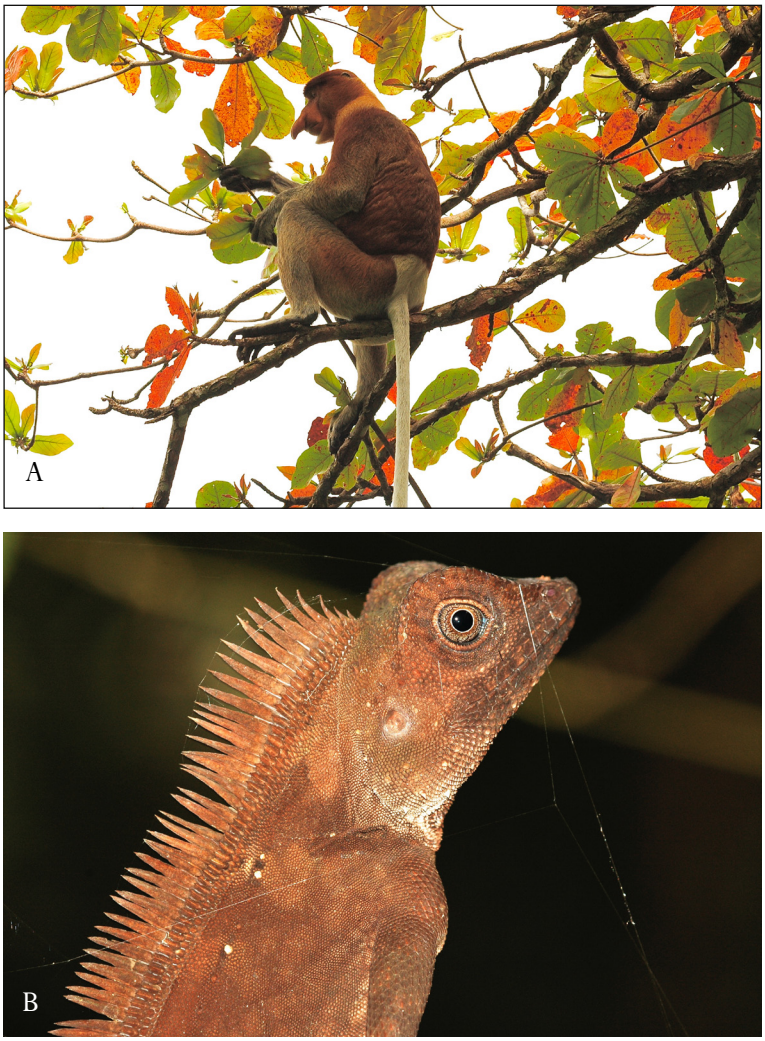

Figure 1. (A) A male proboscis monkey in coastal woodland at Bako National Park, Sarawak, 2005. In Indonesia, reputedly, the locals used to call these animals "Dutch monkeys", because their big noses and pot bellies reminded them of their colonial masters. Photo credit G.T. Reels. (B) An agamid lizard with a spectacular crest, Lambir Hills National Park, Sarawak, 2005. Photo credit G.T. Reels.

The fun began when a middle-aged chap with a basin haircut prepared us some betelnut, wrapped in a leaf, for chewing. Everybody laughed when I warily put mine into my mouth and started chewing it. I spat it out quite quickly, however, because one of Joseph's sisters had just rolled us each a cigarette made with the strong local tobacco, wrapped in inner banana leaf. We puffed away at these to general amusement, and then another of Joseph's sisters brought out some mature (i.e., clear) tuak (rice liquor) and served the two of us a cup each.

Having successfully passed these three tests, the attention drifted and people started quietly leaving. We got to bed around 2300h.'

Figure 2. (A) One of Chief Joseph's three graceful sisters, Long Aton. Photo credit G.T. Reels. (B) I attempt to perform the warrior dance in front of the assembled longhouse community of Long Aton, March 2006. Photo credit Rory Dow.

26 March - '…The villagers were celebrating harvest festival today – John and Luke had already spent much of the day going door to door in the longhouse with the catechist, blessing people and drinking their tuak. We knew that a celebration was planned for the evening, and we went over to the longhouse at around 1930h.

We sat on the verandah as before. A long table had been laid out with numerous dishes prepared by various people from the longhouse. There was a lot of to-ing and fro-ing and an air of happy expectancy, with people from the different rooms each bringing a big jug of new rice wine and placing it by the table. It was white in colour and Luke joked that it was goat's milk (for a while, I was stupid enough to believe him). Then when all was ready we were invited, as guests of honour, to be the first to go up and help ourselves to nosh. The dishes were mainly fibrous vegetables, fish, some pork and of course lots of the new rice. The rice was prepared wrapped in leaves – each parcel contained a generous portion.

We sat down and started eating. The whole longhouse was queuing for the food and presently we were all sat, perhaps 200 people, chatting away happily and enjoying a pleasant feast together.

Then the dancing started. Joseph, as paramount chief, was up first, donning the feathered cap headdress and sun bear skin cape, decorated with hornbill feathers and, rather incongruously, a large 24-hr clock hanging in front from around his neck. He finished to general applause. I should say that the musical accompaniment was provided by two Penan playing sape's. After Joseph had quaffed his compulsory cup of tuak (down in one) it was Michael (a heavy, ponderous dance performed gracefully and with a beatific smile), then one or two other notables, then John (a fine dancer, as we already knew from his performances at Mulu).

Then it was Rory's turn. To great hilarity, Rory bobbed around jerkily, abandoning the smooth, slow movements of the dance for something altogether more akin to a strutting rooster impression. He finished with a flourish and wild applause broke out. "Ror-ee! Ror-ee!" they cried. And then it was me. I did my best but the headdress was too small and kept slipping off. I pushed it back on again, oblivious to the hoots of laughter coming from the assembled throng, and soldiered on, crouching down, extending arms gracefully and so forth, before I was interrupted by one of the head men, who forced the headdress strap under my chin. Rather throttled, I tried to continue for another minute or so (Fig. 2B), dimly aware of John shouting encouragement, then took my bow. I believe it was much appreciated.'

Batang Ai, December 2007

08 December - '…Eventually, we came to a sunlit open spot on the stream with a large log running diagonally across it, at a height of 1m. It was a promising spot so we settled down to see what would turn up. A *Macromia* zoomed

past. Twice. And a mid-sized corduliid, which may have been *Macromidia*. Rory stationed himself at the downstream end of the opening, I at the upstream end, so that we'd have a better chance of nabbing the next anisopteran.

'Presently, I became aware of some excitement among the others, and Gadang called out "Orangutan!" to me. I looked up and there was an orangutan, perhaps 30m away, swinging heavily across the stream canopy. I scrambled over and got my binoculars on it, breathlessly. After a while the orangutan came a little closer and I could distinguish two heads – it was a mother with a baby! Gadang later said he thought the baby was about two months old (they stay clinging to their mothers for a year). The mother showed no inclination to leave, but kept moving around in the trees nearby. At one point she came quite close, such that she was almost directly overhead, and I could discern mother and baby scrutinizing us closely. They were very curious (Fig. 3A).

A few moments later I became aware of other movement in the trees, and a third orangutan appeared – a young male to complete the family set. This seemed too good to be true. Then a pair of hornbills flew in and settled somewhere nearby. A giant tree squirrel ran up a branch. A small monkey leapt from one tree to another. A real Borneo experience. It was marvellous.'

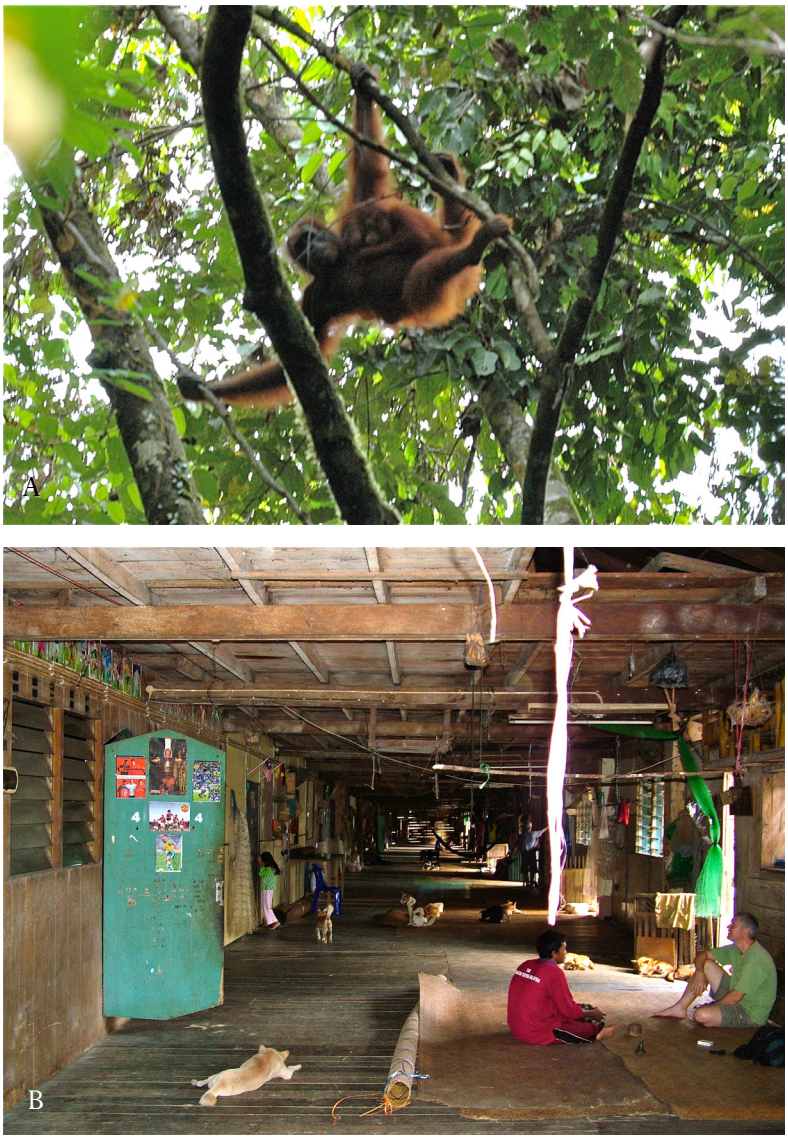

Figure 3. (A) The mother and baby orangutans clambering almost directly over our heads in order to get a better view of us. They were soon joined by a subadult male. Batang Ai, December 2007. Photo credit G.T. Reels. (B) Sitting with Gadang, our National Park guide, in his longhouse home, Batang Ai, Sarawak, 2007. Photo credit Rory Dow.

09 December - '…We got into Gadang's longboat. A fascinating trip back down to park HQ – hornbills flying over the river, herons, kingfishers, a few dragonflies on floating logs. Paid a courtesy call on Melvyn and then back in the longboat to Gadang's longhouse. He had invited us there for breakfast. On the way we saw a fish eagle and a Bornean Diver, slender and graceful, cutting through the air.

It was a nice Iban longhouse, with numerous dogs lolling on the shaded verandah, various hooks, baskets and fishing nets hanging from the wooden ceiling, people cheerfully coming and going, kids running around. We sat on wicker mats opposite the door to Gadang's room (which was surrounded by pictures of Liverpool and Man Utd players cut from magazines) (Fig. 3B). Gadang produced some langkau and then some noodles. A very elegant old lady, perhaps 70 years old, came and sat with us, sitting demurely on one hip with her legs tucked in at the side. She was beautiful. The sun was shining outside and there was a strong sense of a close community living happily together. Very nice.

I went for a pee in Gadang's toilet, which was right at the back of his rooms and had narrow, widely separated floorboards through which you could see the sunlit ground some 12' below.'

Lanjak Entimau, July 2016

13 July - '…We continued our journey upriver on the Sungai Engkari to the field station, but Rory and I were obliged to walk almost all of it, as the shallows and rapids were so difficult that the guys had to punt and haul the longboats most of the way (Fig. 4). Occasionally we reached deep stretches and had to clamber into a boat

Figure 4. A break during the arduous upstream navigation of the Sungai Engkari, Lanjak Entimau, Sarawak, 2016. Rory Dow left foreground. Photo credit G.T. Reels.

for a short distance, but most of the day was a long slog in which we walked along the river bank or (more often) waded the river, which had to be crossed and re-crossed countless times, often in treacherous conditions, although I managed not to fall over once. At the beginning of the hike, almost the first time we entered the river, Bana confidently said "This way", marched into the mid-channel and promptly slipped and got a dunking in the chilly water. After that he removed his T-shirt and spent the rest of the day swimming up the deeper stretches. There were a few stretches that were four or five feet deep when I had to hoist my backpack onto the top of my shoulder.

The six guys from the longhouse, and Clip, were doing quite a lot of fishing, either by hurling a weighted net or by using an improvised spear gun underwater. They cooked up a load of fish on the river bank for their lunch. They had made small baking ovens out of lengths of freshly cut bamboo, about 8cm in diameter and 40cm long, open at one end. One of the guys, Ajie, prepared the fish by cutting out the air bladder then stuffing the fish into the bamboo tubes. These were then put on a wood fire to cook. I should point out that at this point we were still outside the Sanctuary boundary.

It was a beautiful river and I enjoyed the day; nevertheless it was very hard work and we did not reach the field station until 1730h, having started out eight hours earlier. The field station was deserted (too remote to have permanent staff) but very comfortable. There was a generator providing electricity.'

19 July - '…Although the rain wasn't heavy it seemed to kill off all dragonfly activity and after a fruitless hour I turned round and started walking back to camp. As I approached the camp site, which I reached at 1530h, heavy rain began to fall.

Rory and the tuai rumah got back shortly after me and the three of us sheltered under the canvas awning which had been set up over the space where Rory did his specimen processing. We ended up sitting there for two hours as the rain continued to fall heavily. After the rain finally eased, we made two unpleasant discoveries. The first was that our tents were not waterproof. They had become swimming pools. Rory cried out disconsolately at discovering his soaked sleeping bag. Mine was similarly drenched, as was the tuai rumah's. The three other guys, who'd been sheltering in their tents the whole time, had had the foresight to stretch canvases over them, so they were fine.

This problem, serious as it was, was dwarfed by the next problem, which was that the river was rapidly rising. The gentle clear bubbling stream of earlier had swelled into a turbid roaring monster. It was creeping remorselessly, inch by inch, up the bank. From originally being at least 12m from my tent, it had now crept to within 2m. In alarm I packed all the soaking stuff in my tent into my bag, in preparation for abandoning camp. That

would have been dreadful as we would basically have had to sit in the forest, bled dry by leeches, throughout the night.

Mercifully, the river peaked before hitting our tents, and as it started to slowly retreat in the fading light the guys got to work rekindling the camp fires. As darkness was falling we snatched a hurried dinner. The rain continued to hold off, the fires grew stronger, and we slowly dried out our sleeping bags and other wet gear whilst drinking copious quantities of coffee. Eventually we were even able to mop out the pools of water in our tents using one of Rory's t-shirts. We sat around the fires till late, warming ourselves.'

Figure 5. (A) A small arboreal snake at Gunung Mulu National Park, Sarawak, 2005. Photo credit G.T. Reels. (B) Heading up the Tutoh river by longboat in search of dragons and other treasures, Sarawak, 2006. Photo credit G.T. Reels.

22 July - '...the settlement at Nanga Talong is actually very beautiful, set on the outer bank of a sharp bend in the Engkari, which is about 15m wide here. A small tributary joins the Engkari on this bend, and cuts through the settlement in a deep ravine. The two sections of the settlement are linked by a high wooden bridge. Roosters strut through the back-lanes behind the longhouse, among the small chicken coops and pigsties. The village dogs are everywhere. Down at the river, half a dozen or so longboats were berthed, decked out in attractive colour schemes of blue, yellow, green and purple.

I didn't count how many doors the longhouse had but the tuai rumah said it was home to about 200 people. His house, where we were again staying, was mid-way down the longhouse. Rory and I got there just after 1400h, feeling completely shattered. Ten consecutive days of mentally and physically tiring field work had left me feeling more exhausted than I can ever remember from any other field expedition. I had a quick wash then slumped down in an armchair, before gratefully accepting an invitation to lie down on a mattress on the floor. This blissful rest only lasted 20 minutes or so, however, before Bana called Rory and I into the kitchen, where we sat around the table drinking tuak and the last bottle of lankau.

At about 1700h, Bana led me, Rory, Clip and Agie down to the longboat 'jetty' (a rock exposure) for a swim. He took a spectacular tumble as we descended the steep steps down to the river, rolling himself into a ball to protect himself and emerging with his ever-present cigarette still intact in his fingers. We had a refreshing swim in the river, accompanied by about seven or eight of the longhouse kids, ranging in age from about 6 to 12, who had followed us down and could swim like dolphins. It was an idyllic setting and I felt lucky to experience this wonderful communal life that still exists in these remote longhouses.

That evening, children and adults alike wandered in and out of the tuai rumah's house to sit on the floor in front of his television set. It really was a warming experience and so sad that we have lost this sense of neighbourly community in the 'developed' world.'

Lockdown Odonatology – the healing power of nature

Albert Orr [agorr@bigpond.com]

Every morning after I arise, it is my habit to settle into a deep and comfortable armchair in a sunny north-east corner of my house. There I read the daily broadsheet, easing myself into the day with my first, second and third cup of tea. Lately, the newspaper has shrunk alarmingly, (no sport is played these days), and the contents are dismal. Yesterday reported the millionth global case of CoVid-19, and the 50,000th death. It was while reading this that I happened to glance up at the un-pruned crotons that grow eccentrically outside my living room window. There, in glorious sunlight, perched a large, red, male *Orthetrum villosovittatum*, set in an azure sky.

Calm came over me - my vision sharpened – this was my *Aka Tombo* moment[1] – Gazing at the insect for several minutes I forgot the grim statistics, and the growing danger that lurks even in my tiny patch of earthly paradise. This vivid, chilli-bright dragonfly recalled the healing power of nature, and set me on a happier train of thought.

Later that morning, craving sunlight and vitamin D, I went for a short walk. Keeping clear of the paths and the furiously pedalling cyclists that infest the area, I paddled ankle deep in the clear salt water at the edge of the tree-lined lagoon. It was beautiful. After recent rains all nature was alive and buzzing. All about there was a feeling of rude life and rebirth; butterflies whizzed by, courting, mating, ovipositing – in wonderful variety – so many fresh-emerged. Migrating Blue Tigers and Caper Whites pressed on in steady drifts. Dense clusters of Harlequin bugs massed in the cotton trees. An intensely blue *Ischnura heterosticta* perched in the reeds, and two skittish *Diplacodes bipunctata* were practising social distancing along the water's edge. It was all wonderfully uplifting, and starkly contrasted with the human world, hunkered down, cowering, anxious - the perfect antidote to the black dog that stalks us all at this time.

Water is always soothing. But in time of pandemic it offers a special sanctuary - a clean and pure haven. Dragonflies are its most charming ornaments. During home lockdown, your dragonfly pond may be your best source of therapy. And as your world contracts, you may just see more clearly small miracles, that are usually hidden in plain sight, as you dash past them headed for far off adventure.

My Pond

I have two ponds, but these days the larger one in the north-facing front garden provides much the better Odonata habitat. It occupies about 13 m^2. Its outer margin traces an irregular pear shape; in the middle is an egg-shaped island of about 3 m^2 leaving about 10 m^2 of open water (Fig. 1). It was constructed by my late father in 1966. The soil here consists of a two metre deep layer of almost pure silica sand. Using a narrow trenching shovel, my father dug the outlines of the pond to 60-70 cm depth. This provided a mould, which he filled with concrete to make the walls. Once these were set we dug out the enclosed area, in three places to a maximum depth of about 1.3 metres. The bottom was sealed with a thick layer of concrete. It was filled with water, planted with several varieties of water-lily and several other hydrophytes, and stocked with goldfish. Within a few years it had developed into a thriving ecosystem, with many new plants appearing, as well as dragonflies (Fig. 2A) and many other aquatic insects.

At the time there were only a few scattered buildings in the area. We were surrounded by 'wallum' heath and open *Melaleuca* forest. Looking out the kitchen window it was common to see grey kangaroos grazing at a grassy patch just 40 m away, and echidnas often burrowed into the fenced backyard. Fortunately, I had begun collecting insects in 1965 and from 1969 on, I kept a nature diary that I continue to this day. So, although it was impossible for me to identify odonates (the first affordable field guide to Australian butterflies had only been published in 1966), I have, or have had historical collections that indicate a changing local pond fauna over five decades. As the original habitat remains preserved in a small 50 ha national park

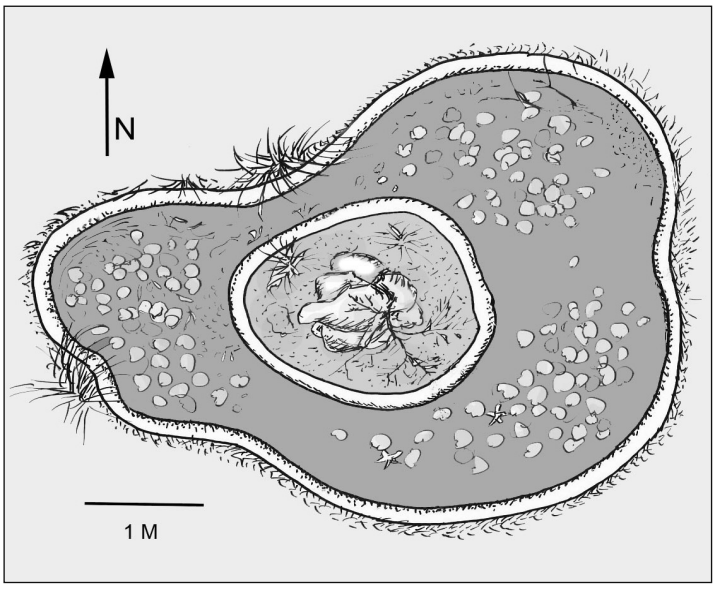

Figure 1. The pond seen from above

1 Aka Tombo (Red Dragonfly) is a much loved Japanese folksong. Its words are wistful and nostalgic, but it also evokes feelings of joy, transporting the singer back to a halcyon childhood.

less than 500 m distant, (see Orr, 2013 for a description of this site) it is possible to judge to what extent changes in the species present are due to the otherwise total urbanisation of the immediate area versus altering distribution patterns with climate change.

The Odonata of my pond

Over fifty years, at least 22 species of Odonata have been recorded at the pond. This does not count occasional sightings of hawking aeshnids or larger libellulids, but includes all species that have established territories there and/or bred in the pond. Eight to nine of these species are or have been common, either permanently or temporarily resident at the pond. These are listed in Table 1.

The most significant change that has occurred since the 1970s is that the following species that were formerly common have virtually disappeared: *Pseudagrion microcephalum*, *Orthetrum caledonicum*, *Orthetrum sabina*, *Pantala flavescens*, *Rhyothemis phyllis* and *Tramea loewii*. All these species remain common in the area, as evidenced by prey taken by Rainbow Bee-eaters (*Merops ornatus*) in the nearby national park (Orr 2013). These species are also frequently seen closer, foraging on the southern shore of Currimundi lake, which is even nearer, but being saltwater does not offer breeding habitat. Evidently the dense urbanisation in the area is sufficient to discourage visits to the pond, even from 150-200 m distance. Species that still cross this barrier include *Adversaeschna brevistyla*, *Hemicordulia australiae* and *Diplacodes bipunctata* (Fig 3F), although the latter is now rarer than previously. It is doubtful if *Anax papuensis* (Fig. 4C) is deterred by these barriers as it ranges far and wide, often patrolling the precincts of the garden, but may generally find the pond too small to invite oviposition. *Austrolestes leda* (Fig. 3I) has always been sporadically common, but recently it has only appeared when there is standing water in the national park, a rather irregular occurrence during the recent protracted droughts in Australia. The most obvious positive changes have been the increase in numbers of *Orthetrum villosovittatum* and *Ceriagrion aeruginosum*. Although always common at the pond, they have now become co-dominant, and are almost always present and breeding during the warmer months. Since 2010 the generally uncommon *Diplacodes melanopsis* has appeared most years and has bred in the pond. Over the last few years the resident species, almost always present at the pond as adults or larvae are: *Agriocnemis pygmaea*, *Ceriagrion aeruginosum*, *Ischnura aurora*, *Adversaeschna brevistyla*, *Hemicordulia australiae*, and *Orthetrum villosovittatum*. (Figs 2B-D, 3A-C, 3H, 4A-B,)

The recent *Agrionoptera insignis* record (Fig. 3E), made during my lockdown period (3 April 2020), was a first; then on 11 April, two females visited, and one oviposited. It remains to be seen if it becomes a regular visitor. It is a common northern species but lately there have been quite a few records from Southern Queensland - see [Link].

Figure 2. (A) Photo of the pond, looking south. (B-C) *Agriocnemis pygmaea*. (B) Male (C) Female. (D) *Ceriagrion aeruginosum* in tandem.

Figure 3 (A-C) ***Orthetrum villosovittatum*****. (A) Male. (B) Pair in the wheel. (C) Male guarding a freshly mated young female. (D)** ***Ischnura aurora*** **ovipositing. (E)** ***Agrionoptera insignis*****. (F)** ***Diplacodes bipunctata*****. (G)** ***Austroagrion watsoni*****. (H)** ***Hemicordulia australiae*** **in wheel, (I)** ***Austrolestes leda*****.**

What makes for a good dragonfly pond?

There are two main features of a pond that enhance its attractiveness to Odonata. One is its proximity to natural habitat and source populations, the other the structural and biotic heterogeneity of the pond and its immediate surroundings.

Even in 1966, when my pond was constructed, I could not expect a very diverse fauna. There is little standing freshwater in the immediate neighbourhood. I know of a slightly larger pond in the nearby hinterland, in regenerating open sclerophyll forest, where at least 40 species have been recorded, including the probable first sighting of *Anax gibbosulus* in southern Queensland. Such riches were never to be hoped for here.

However, since about 1990, following intense urbanisation of the immediate area as well as most of the land for several kilometres around, there has been a marked reduction in the number of species seen regularly at the pond. Similar declines have occurred in certain butterfly populations.

Figure 4 (A) *Hemicordulia australiae* male patrolling. (B) *Adversaeschna brevistyla* ovipositing. (C) *Anax papuensis* patrolling overhead.

Pond-care and activities

Although as individuals we cannot arrest human 'progress', even in an urban pond, we can still take direct actions to enhance the pond's attractiveness to Odonata. The first is to manage the water habitat. It is important to maintain the highest possible heterogeneity with plenty of microhabitats on offer. The hydrophyte flora should be as rich as possible, and it is always important to make sure there is a balance between the extent of vegetation cover and open water. When the pond is choked with water lilies few odonates will be seen. However, within just a day or so of clearing vegetation to allow access to open water, the resident species usually return in numbers. Although it is quite common to see a single male *O. villosovittatum* guarding a choked pond, few females come to oviposit. Similarly, the numbers *of C. aeruginosum* can quadruple overnight following a cleanout.

The other important thing is to allow untidiness in the vegetation around the pond, even permitting straggly weeds to flourish. This provides perches and shelter for the adults, but perhaps more importantly, it encourages numerous small insects which are the prey especially of the smaller damselflies, some of which, such as *A. pygmaea* and *I. aurora*, probably live their entire lives at the pond or in its immediate vicinity.

Having your own, well attended dragonfly pond provides many opportunities for practising hardship-free natural history. It is easy to collect fresh laid eggs and follow their development in the laboratory. You can make many interesting behavioural observations, including marking individuals to monitor residence times and longevity. Regular counting following a standard protocol can yield valuable information on trends in abundance. In my pond the relative dearth of species is an advantage, as I can concentrate on a single species that is present at high density. For example at present *C. auruginosum* is mating and ovipositing from about 1000-1300h. Otherwise they are perched or foraging, gleaning tiny prey from the pond side vegetation. There are just enough to keep track of without being overwhelmed.

Sometimes one sees predators in action. The water spider *Dolomedes facetus* (Fig. 5A) is common on the pond, and often surprises mating or ovipositing damselflies. The golden orb weaver *Nephila plumipes* (Fig. 5B) frequently constructs webs across flight paths. Their webs typically catch a few damselflies but large Anisoptera usually avoid or break out of them. Once I saw a tandem pair of *C. aeruginosum* with the female trapped in a *Nephila* web and the male flying strongly as he tried to pull her free, warping the whole web behind him. I rushed inside for my camera, but by the time I returned he had abandoned her, and she was being parcelled in silk by the spider. The pond offers many opportunities for refining your photographic techniques, and for sketching from life.

Notes from a very small island

I have always kept an eye on species present in the pond, and often witness interesting behaviour. But now I am in virtual lockdown, and as part of my CoVid-19 sanity maintenance program, each morning from about 1030 – 1100h I station myself on the island with a camera, and watch and photograph for about an hour. I have a vague hope that one day I might fluke a shot of an ovipositing *Orthetrum* female, with the guarding male hovering nearby in focus. This has not yet happened!

At present I am enjoying watching the whirl of reproductive activity around me. In a 40 minute period the resident male *O. villosovittatum* will have mated for several minutes with three females, guarded them while they oviposited if not occupied with his next mate, fought off another male, fought the *Agrionoptera insignis* which accepts less prominent perches, and also re-mated two or three times for a few seconds with returning females before they resumed oviposition, rhythmically flicking their eggs up onto damp moss along the waterline. At any given time there are two to four pairs of *C. aeruginosum* ovipositing in tandem, often into lily pads, and one or two *A. pygmaea* females ovipositing into thin green stems and leaves just below the water surface, either alone or with a male guarding nearby. There have also been brief visits from *Diplacodes melanopsis* and *D. bipunctata* (both sexes, with the female of the former ovipositing alone) as well as single females of *Austroagrion watsoni* (Fig. 3G), *Austrolestes leda* (Fig. 3I) and *Ischnura heterosticta*, the latter ovipositing just once.

Figure 5. (A) Water spider (*Dolomedes facetus*). (B) Golden orb-weaver (*Nephila plumipes*).

Yesterday a single young female *Ischnura aurora* visited and oviposited alone for 20 minutes all around the pond. When I judged her nearly finished, in order to conclusively establish her identity, I caught her in my fingers and, with mixed feelings, killed her by freezing. I normally have no qualms about collecting - it is a necessary scientific activity. But by communing daily with the Odonata of my pond, I have established a spiritual connection that precludes interfering with the natural rhythm of their lives. Seemingly, my benevolence is rewarded, as I am permitted to approach the residents ever more closely as they accustom to having a human as part of the landscape. I am waiting for the day when I am used as a perch. Then I will feel truly blessed.

I used to say it was impossible to spend a day in the Bornean forest without witnessing something utterly magical. The same is true if you sit for a day in the tiny national park on the north shore of Currimindi lake during the breeding season of the Rainbow Bee-eaters from November to early January. A powerful telephoto lens and the rapid-fire profligacy allowed by digital photography has thrown up many secrets of the natural world that take place regularly before our eyes. Many times I have examined casual photos to see something I never suspected – a Caspian tern with an identifiable mackerel in its bill; a crow emerging from an ibis nest with an egg in its bill; a Drongo vomiting after incautiously swallowing a *Delias nigrina* butterfly. These things happen so swiftly in life they are easily missed.

As my world contracts I find there is as much magic as ever – one just needs to focus a little closer. I cannot spend two hours beside my pond without seeing something enchanting. Soon it will be winter and the dragonflies will disappear – no matter – the winter-flying *Delias* butterflies will begin to appear. In the trees around the pond four species of mistletoe grow – all larval host-plants. And as I write, looking out the window late on a Sunday afternoon, the migrating Blue Tigers (*Tirumala hamata*) are beginning to mass in the trees overhanging the pond. I can see about twenty on the wing right now. Yesterday evening more than 100 were roosting there by sunset. As in time of war, life must go on, and we who love nature must be grateful for the inestimable gift our passion has bestowed on us; the ability to find beauty and meaning in time of adversity. Just as Maus Lieftinck did when he reared and preserved the unknown larva of *Potamarcha congener* while in military internment on Java during World War II. He too, faced an uncertain future.

Acknowledgements

I thank Matti Hämäläinen, Heinrich Fliedner and Graham Reels for reading and commenting on the manuscript.

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Table 1. Species recorded from the pond, 1966-present.

Species	Occurrence	Breeding	Notes
Austrolestes leda	Occasionally common	Breeds most years	Seasonally abundant in nearby fresh water bodies.
Aciagrion fragile	Sporadic and rare	Probable	May be under recorded
**Agriocnemis pygmaea*	Common, regular resident	Regular	Generally present October to May
Austroagrion watsoni	Sporadic and rare	Not confirmed	Common on nearby water bodies
**Ceriagrion aeruginosum*	Common, regular resident	Regular	Generally present October to May -dominant zygopteran
Pseudagrion microcephalum	Rare since 1990	Not confirmed	Common on nearby water bodies, common pre-1990
**Ischnura aurora*	Common, regular resident	Regular	Generally present November to April
Ischnura heterosticta	Occasionally common	Confirmed sporadically	Common on nearby water bodies
**Adversaeschna brevistyla*	Visits pond to breed	Fairly regular	Commonly hawks in garden – common prey of nearby nesting Rainbow Bee-eaters
Anax papuensis	Visits pond occasionally to breed	Occasional, normally revealed by exuvia	Very commonly hawks in garden
Ictinogomphus australis	No records for 20 years	Not confirmed	Occasionally visited prior to 1990
**Hemicordulia australiae*	Regularly visits to breed	Larvae usually present	Commonly hawks in garden – common prey of nearby nesting Rainbow Bee-eaters
Aethriamanta circumsignata	Single record, one male 1998	improbable	Uncommon in nearby water bodies
Agrionoptera insignis	First record, one male, 3/4/20	Confirmed 11/Apr/20	Rare in southern Queensland
Diplacodes bipunctata	Rare since 1990, Formerly common	Confirmed in the past	Common on nearby water bodies
**Diplacodes melanopsis*	Occasionally present since 2000	Fairly regular	Uncommon on nearby water bodies
Orthetrum caledonicum	No records since 2005	Not confirmed	Common on nearby water bodies and regular visitor to pond before 1990
Orthetrum sabina	Rare and sporadic	Previously regular	Formerly common with few records since 2010
**Orthetrum villosovittatum*	Common resident	Regular	Present October to May – dominant anisopteran
Pantala flavescens	Occasional visitor	Not confirmed	Common on nearby water bodies
Rhyothemis phyllis	Occasional visitor – more common before 1990	Not confirmed	Common on nearby water bodies
Tramea loewii	Occasional visitor – more common before 1990	Not confirmed	Common on nearby water bodies

* species currently resident at the pond as adult or larva.

Sampling dragonflies in one of the few Covid-19 free places: Introducing the Pacific islands of Wallis & Futuna

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Any time I open the map of the Pacific I wonder at this natural phenomenon. The world's largest ocean indeed, but also the largest terrestrial territory within a water basin. A huge series of islands and island groups stretched between Asia and Australia in the west and the Americas in the east, including New Zealand's subantarctic islands, Micronesia, Easter Island, Galápagos, the Hawaiian islands and many others. An enormous geographical unit where notions of large and small, wide and narrow, ancient and recent are so relative depending on the point of view of researchers or local island residents!

Searching for a particular biogeographical pattern in this ocean is a challenge which I have struggled to comprehend for several years. I thought of getting some answers to my questions by visiting the main islands within the various groups and taking a 'representative sample' from each. Not working that way! This is a lesson I learned in 2012 on the island of 'Eua, Tonga. There on a territory of about 4 km^2 one can find the entire world population of *Teinobasis fatakula* Marinov & Donnelly, 2013. Skip this island and you miss the species for any kind of analysis. Once on Viti Levu, Fiji you go anywhere else but Nadarivatu and do not find *Nesobasis ingens* Donnelly, 1990. That is why getting a grip on the island Odonata biogeography should be done by constant sampling on every island across the Pacific.

The islands of Wallis & Futuna were in my plans for the very distant future. I found a hydrobiological study which resulted in 10 species from both islands published in Papazian et al. (2007). None of them is endemic to these islands and I already have samples of these species from other island groups. However, in June, 2019 Régis Krieg-Jacquier, a very close friend of the late odonatologist Daniel Grand, sent me a photo of a very dark *Rhyothemis* sp. from Wallis (Fig. 1A). Régis told me a very intriguing story about the French citizen Philippe Duvernay visiting his brother Jean-Marc Duvernay, a science teacher at Alofivai College at Lano, Wallis Island. On 18th June 2019, going back to France from his holiday Philippe posted the above picture and a small comment on the Facebook Group 'Odonates de France et d'ailleurs' [Link]: "Bonsoir, alors moi, j'y connais rien mais j'ai pris celle ci à Wallis, dans le Pacific sud. Je ne sais pas si elle est endémique, en tous cas, elle est assez fréquente sur l'ile. Merci à ceux qui pourront m'en dire plus." Twenty nine comments followed the post with Benoît

Figure 1. (A) *Rhyothemis* sp., Lake Lanutavake, Wallis Island. Photo credit: Philippe Duvernay. (B) *Rhyothemis princeps*, Lakefield NP, Queensland, Australia by courtesy of Günther Theischinger. Photo credit: Leonard Müller.

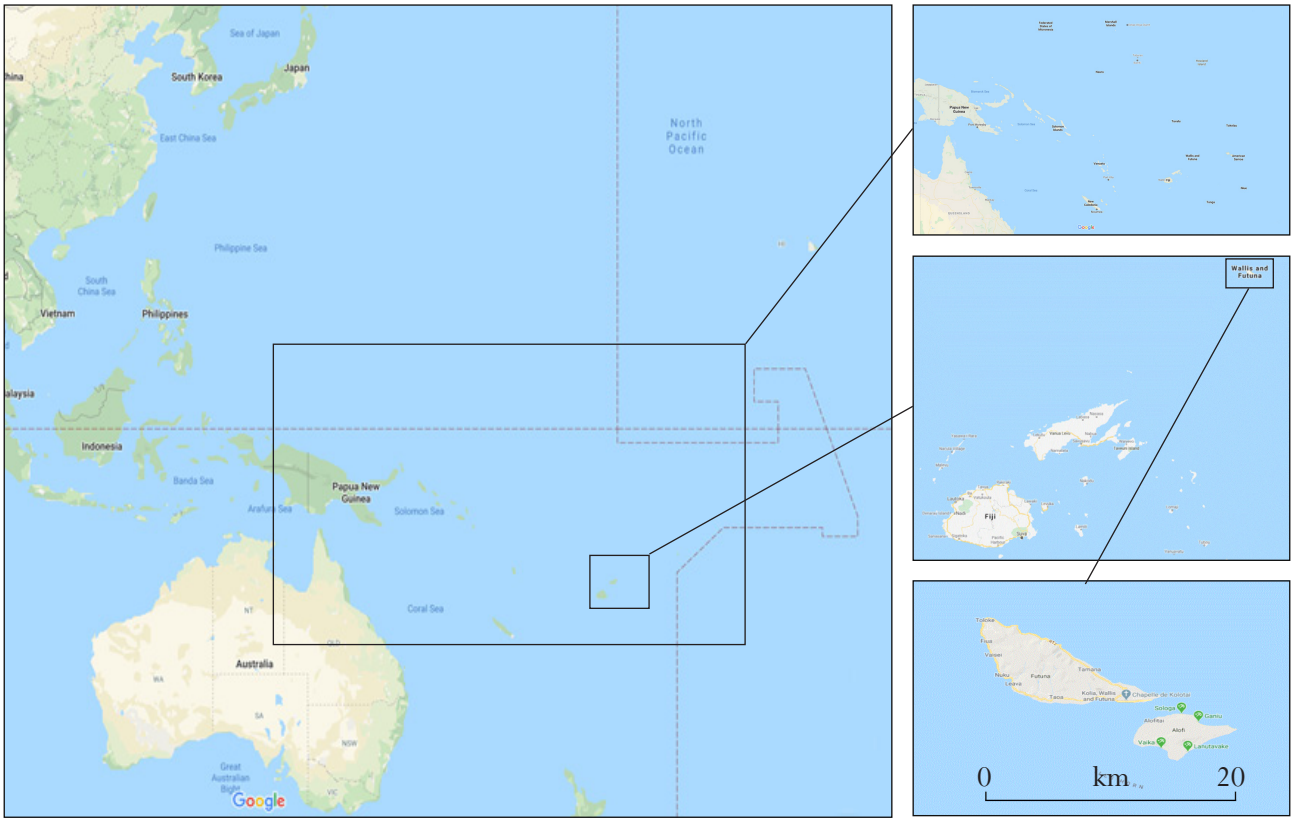


Figure 2. Maps showing location and relative size of Wallis & Futuna (Google Maps).

Guillon suggesting the identification as *Rhyothemis princeps* Kirby, 1894, known only from Australia and New Guinea (Theischinger & Hawking 2006). The similarity is obvious from the photo provided in Figure 1B, however the relationship and origin of the Wallis population is a complete mystery! Obviously the species is common on Wallis as evident from a picture taken at Lalolalo Lake and uploaded on 10th September 2014 on a weblog: 'Erhan in Wallis' [Link]. If it really is the same species how is it possible that *R. princeps* has not colonised any of the other islands between its known range and Wallis, which is ca. 3,250 km from Australia? We are talking about some of the largest islands in the Pacific, such as the Solomons, New Caledonia, Vanuatu and Fiji in comparison with Wallis, a small island that one cannot see on the map of the Pacific unless extremely zoomed in (Fig. 2)! Another possibility would be that it was a very dark *R. regia chalcoptilon* Brauer, 1867 which is the only species from the list published in Papazian et al. (2007) which is closer to the one photographed by Philippe. However, how is it that the wing colouration of *R. r. chalcoptilon* is almost unchanged within its entire currently know range from the Northern Mariana Islands to Samoa (cf. Fig. 3) and for some reasons Wallis has developed its own form or variety?

While asking these questions I remembered an email from Rosser Garrison who just a few weeks prior had identified *Pseudagrion microcephalum* (Rambur, 1842) from some material brought to his attention. In several other studies (Marinov 2012; Marinov et al. 2015, 2019) I have been suggesting a revision of the genus in the Pacific. I thought I had the last piece of the puzzle from my trip to Vanuatu with Seth Bybee in 2017 (Marinov et al. 2019) where the species was very common, but Rosser surprised me with this species never reported from Wallis & Futuna before.

Combining the dark *Rhyothemis* sp. with the so much desired *P. microcephalum* changed my plans completely and Wallis & Futuna moved up in my wish list as a priority destination. Martin Schorr helped with funds from the International Dragonfly Fund (IDF) and then there was me on 28th February 2020 sitting at the departure lounge of the Auckland airport exchanging

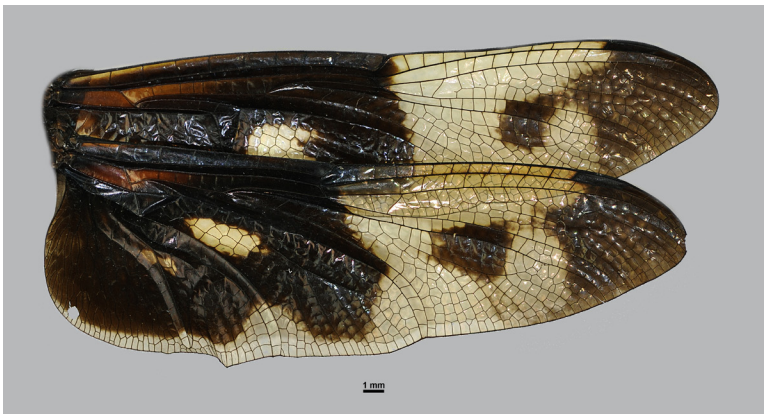


Figure 3. *Rhyothemis regia chalcoptilon*, wing colouration of a specimen from Samoa (Figure 19a from Marinov et al., 2015).

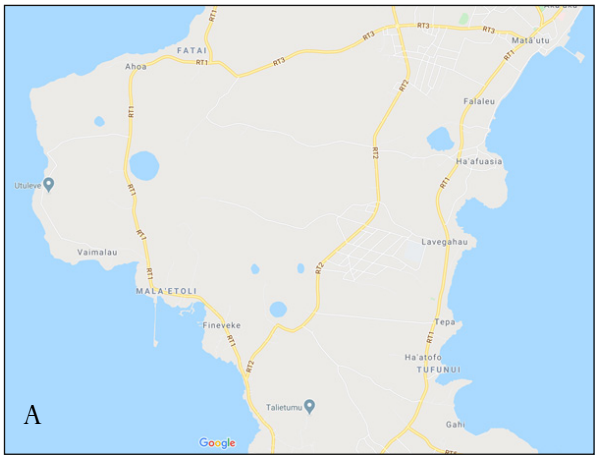
last news and jokes with my friend before I boarded the plane. This is how I found out about the first Covid-19 case in New Zealand. I was glad I was leaving it behind for the next two weeks – time well spent in a hot-hot environment with 5-6 litre of daily drinking water and the compulsory ice cream … at least once a day.

Wallis and Futuna are two completely different geographical units. At least this is how they look to a non-geologist/geographer. Wallis is mostly flat with no running waters and (in my opinion) the island with highest concentration of freshwater lakes (Fig. 4A). I don't remember seeing so many lakes on a single island in the Pacific. Some of them are of volcanic origin with so perfectly circular shape that it looks like the cone has been made with the help of a giant pair of compasses (Fig. 4B). 'Cone' is probably not a proper word as the sides are nearly vertical with almost no slopes. Unlike other volcanoes where you would normally climb up to look down the crater here you walk on a flat surface, step aside from the road and gaze at the sun lit blue touched with the mat of fresh vegetation growing on the bottom. A large barrier reef encompasses the entire island (Fig. 4C).

Futuna and Alofi (an island just SE of Futuna) do not have the reef around them and it looks like the entire islands have been volcanos (Fig. 5A). The slopes of Futuna are carved with rivers in every direction sprinkling waters over some of the most beautiful rock formations (Fig. 5B) that I've seen at the bottom of the river beds. I managed to visit two lakes up there thanks to my guides Penisio Luaki and Silino Savea organised by Didier Labrousse from the Territorial Environnemental service.

Speaking of people helping me I'm going back in my thoughts to give thanks again for the great hospitality and generous assistance of my main hosts Jean-Marc Duvernay (the main 'culprit' for this trip) on Wallis and Joëlle Vincent on Futuna. Thanks to them the small societies of the two islands quickly learned about the studies of the 'libellules' and we even had some 'local endemic species' for dinner (Fig. 5C). We have had very pleasant meetings and talks with Isabelle Ramé, Lotolelei and Filipo Manufekai with their little boy Ebrahim, Savelina and Ivanoe Ugatai, Florian Le Bail, Stéphane Lepelletier and Alain Tesan, but the most unusual of this trip was me teaching a lesson at the Sisia d'Ono College on Futuna. Organised by the English language teacher at the college, Pierre Cabon, I spent one hour talking about my mission concerning the dragonflies of the Pacific.

The results from this mission will be published later in the IDF-Reports journal. Here I just wanted to share my deepest gratitude to all people who were with me during this most unusual trip done in the time of growing concern about the spread of Covid-19 around the world. Wallis & Futuna (Fig. 5D) didn't have the virus (and still don't have it now!) during my stay but we were hearing about the casualties around the globe. The virus wasn't the main subject of our talks in Wallis & Futuna but it was taking its toll on the life on the islands. The common welcoming tradition of French people to hug with a kiss on both cheeks was banned on the island of Wallis, so when



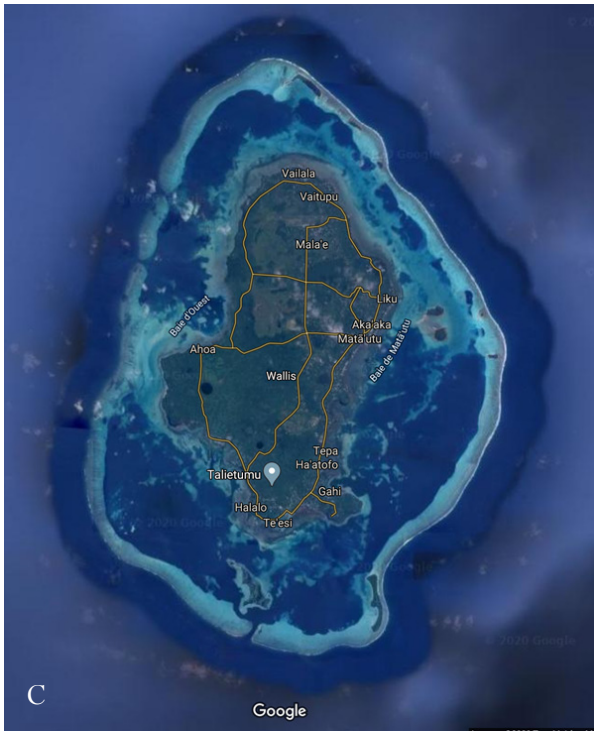


Figure 4. (A) Google Map image showing the southern part of Wallis Island with the largest lakes. (B) Lake Lalolalo, Wallis Island. (C) Google Map image showing the reef around Wallis Island.

we visited another science teacher (I will spare her name) she waved hands in a negative gesture warning me: "No hugging and kissing!" The islands are completely isolated now with no touristic flights or boats but only freight. However, holidays in Wallis & Futuna are not so difficult and I suppose locals are happy to live in their little paradise where warm lagoons and beaches are at their doorsteps (Fig. 5E-F).

I left this paradise bringing specimens from 14 species from the two islands. It was a very lucky escape for me at the last moment before they isolated the islands of Wallis & Futuna and before New Zealand had also officially declared a complete lockdown. My dragonfly specimens were safely transported to our lab at work which, just like many other facilities in the country, is locked up for non-essential business. Unfortunately I can't convince the government how essential it is for an entomologist to have access to his specimens. The isolation from unfinished manuscripts is very upsetting of course, but the discussion platforms with colleagues are unstoppable in the time of digital technologies. Wishing all my colleagues a very productive self-isolation period with many manuscripts finalised, planning for new trips and sharing the brilliant research ideas that I know many of us have developed during the pandemic times staying home and looking out of the shuttered windows!

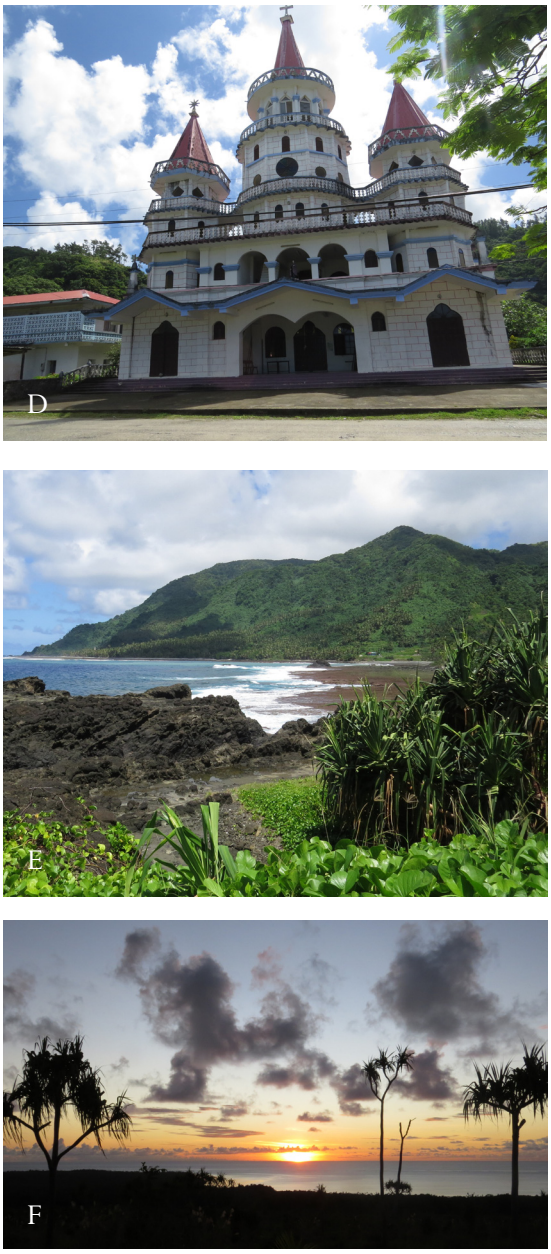


Figure 5. (A) Google Earth image showing Futuna and Alofi. (B) Rock formation at the bottom of Vainifao River, Futuna Island. (C) 'Dragonflies' for dinner served by Jean-Marc Duvernay. (D) Church on Futuna Island. (E) East coast of Futuna Island. (F) Sunset on Wallis Island.

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A memorable encounter with *Platycnemis phasmovolans*, the 'Flying Phantom Featherleg' in Laos

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In late April 2002, during a longer stay in Thailand, I had an opportunity to visit and study the dragonflies of Laos by virtue of arrangements set in place by Dr Naoto Yokoi (Fukushima, Japan). Together with his colleague Mr Vilaysak Souphanthong (Vientiane, Laos), who kindly drove me there from Vientiane in his car, I visited the Kaew Neua Pass area in Bolikhamsai province, some 30 km eastwards of Lak Sao. As soon as we arrived on the afternoon of 27th of April, we visited, for two and a half hours, a few streams at an altitude of ca 650–730 m asl. for a brief preliminary survey. There we spent the following two days, surveying two of these streams from 9 AM to 4.30 PM.

My main goal was to see the magnificent and rare demoiselle species *Archineura hetaerinoides* (Fraser, 1933), which Dr Yokoi had found there on 22 March 2000 (Yokoi, *in litt.)*, and again on 1–2 May 2001 (Yokoi & Kano, 2002). We saw several individuals of both sexes of this giant calopterygid. We also recorded over 40 other Odonata species, several of which were undescribed. One of these discoveries was, without doubt, among the most thrilling moments of my nearly 60 years of chasing Odonata. This is an account of that moment.

A ghostly sight in the shadow

The most rewarding site, where we concentrated our efforts, was a stream a few metres wide with numerous large boulders. Owing to it being the end of the dry season there was stagnant water in some parts of the stream bed.

At 11 PM, on the 29th of April and our last day in the field, I was crossing this stream towards its more densely forested eastern side, when I spotted something extremely unusual two or three metres in front of me. A bunch of dancing white fans was approaching me extremely slowly, coming around a shadowed bush through a small gap in the vegetation close to the stream bank (Fig. 1A). At first, I had no idea what this apparition was. The heavy contrast of sunlight and dark shadow diminished visibility. As it came close, I finally realized that it was a damselfly with prodigiously broad, flattened tibiae. Encountering such a creature my reflex taxonomist's reaction was to swing my net and secure the specimen at once, rather than first studying its behaviour or attempting to photograph it. Mr Vilaysak and I had already arranged to go to the other nearby stream at 11.15 AM. So, unfortunately, I did not have time to look for more specimens. However, when we returned at 2 PM, I had two more hours left to search for this damselfly. I managed to collect two more mature males and photograph a teneral male and a female, both perching on a twig. I have always found that working with a net and camera at the same time is extremely difficult. This was just before digital SLR cameras came into common use, and I was using slide film (Fuji Velvia 50ASA). Unfortunately, I managed only a few rather blurry shots of the species. The male disappeared quickly before I had a chance to take another shot. Although poor, I illustrate the photo of the male (Fig. 1B), because it shows the salmon pink colour of tibiae found in young males.

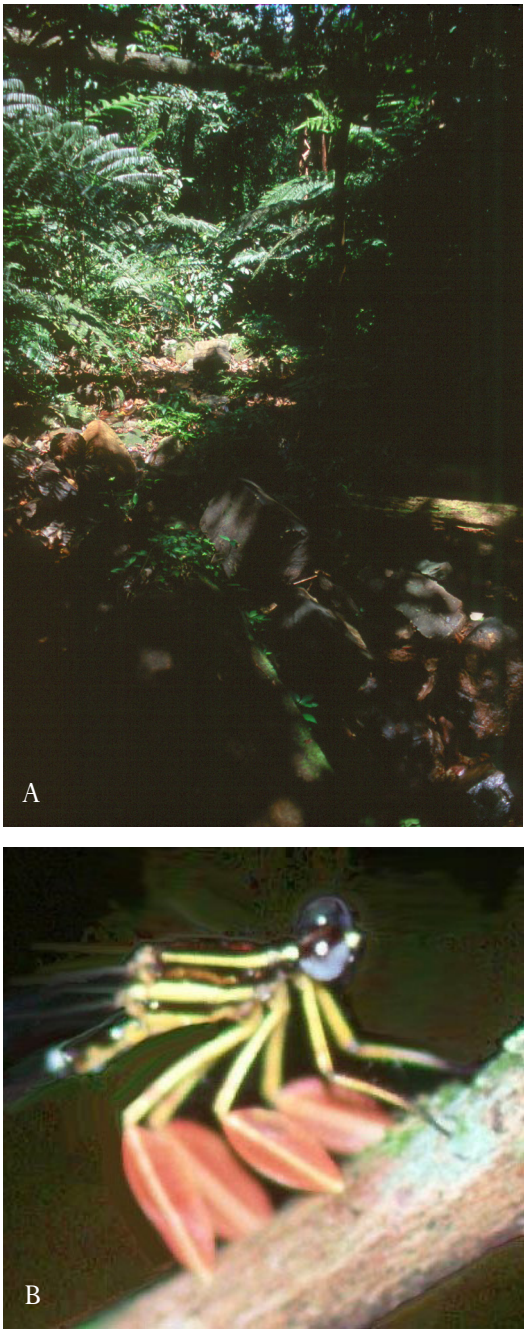

Figure 1. (A) The site in Laos where the 'flying phantom' was first seen on 29 April 2002. (B) A teneral male of *Platycnemis phasmovolans*, photographed at the type locality of the species in Laos on 29 April 2002. Photo credits: Matti Hämäläinen.

Description of *Platycnemis phasmovolas* Hämäläinen, 2003

From the start I realized that the ghostly damselfly must be a new platycnemidid species. When I reported my results, including

this novelty, to Dr Yokoi, he replied (1 August 2002) that also he had found it, and collected three males and one female at the same site between April and May in 2001. He took them at a small, two metre wide pool, on the opposite side of the stream, some 20 metres from where I found the species. Dr Yokoi also wrote that he planned to describe the new species in his forthcoming paper on the Odonata of the Lak Sao area. However, the new species was not described in his article, published on 30 November 2002 (Yokoi & Kano, 2002). Then, in an email dated 14 February 2003, Dr Yokoi asked me to describe it, and subsequently sent me a female specimen.

Figure 2. (A) Habitat of *Platycnemis phasmovolans,* a partly dry seepage, beside a forested stream in the Kaew Neua Pass area in Laos, discovered on 6 May 2016. Photo credit: Naoto Yokoi.

I was pleased to be given this unique privilege, and began work on a paper describing the new species. I thought that such a remarkable creature deserved an evocative species epithet. Therefore, I contacted Dr Reijo Pitkäranta, of the University of Helsinki, a recognized Latinist, for advice. I told him the story of its discovery, when in a dark murky jungle, I first saw only dancing, ghostly white fans moving very slowly towards me. He suggested the name *phasmovolans*, which is a combination of the Greek word 'phasma' (= ghost) and the Latin word 'volans' (= flying). And so the species was named *Platycnemis phasmovolans*. It is slightly surprising that this combination of two common words, despite being a combination derived from two classical languages, appears to have never been used before, perhaps because it was considered bad form to mix Latin and Greek. Even today, the only Google search hits for the word "phasmovolans" refers to this insect.

I submitted the description (Hämäläinen, 2003) to the Japanese journal *Tombo – Acta Odonatologica Japonica*, since the article also included a note on the forgotten taxon *Platycnemis bilineata* Bartenev, 1910, described by a male specimen from Japan. This taxon was synonymized with *Pseudocopera annulata* (Selys, 1863).

Attempts to rediscover *Platycnemis phasmovolans* in Laos

Ten years later, in late April 2012, I had an opportunity to visit the type locality of *Platycnemis phasmovolans* for the second time. Because Sami Karjalainen and I needed good photographs of various calopterygid damselflies for our planned book *Demoiselle damselflies: Winged jewels of silvery streams* (Karjalainen & Hämäläinen, 2013), we included the Kaew Neua Pass area on our itinerary; we wanted especially to photograph *Archineura hetaerinoides* and other calopterygoid species present in the area. Since this would also be a possible opportunity to photograph *P. phasmovolans* in life, and to observe its behaviour, we timed our visit to be at the same time of year as my previous visit. We arrived at Lak Sao in the evening of the 27th of April 2012 and spent the following four days at the same streams visited ten years ago. We observed over 30 species, most of them the same as seen in 2002. Sami managed to get some good photos of *Archineura hetaerinoides* and some other species, but unfortunately there was no sign of *Platycnemis phasmovolans*. The habitat was unchanged from ten years ago. The weather was very hot, and it was sunny all day long. Obviously the rainy season had not yet started. During my visit in 2002 at the same time, some rain had already fallen, although the weather was quite sunny during my stay. It seems likely that *P. phasmovolans* emerges at the start of the rainy season, which in Laos is usually in May.

In early May 2016, during a visit to the Kaew Neua Pass area, Dr Naoto Yokoi had better luck. He wrote (*in litt.*) that the environment at the type locality site had already been degraded, apparently due to flash flooding during a typhoon, and *P. phasmovolans* was not seen there. Fortunately, on the 6th of May, he found a new small population at a semi-stagnant seepage (Fig. 2) alongside a forested mountain stream at ca 550 m asl, a few kilometres southwest of the type locality. He also managed to take excellent photographs of a male and a pair in copula (Fig. 3A-B).

Discoveries in southern China

On Googling '*phasmovolans*' to gather material for this article, I was pleasantly surprised to learn that this species has now been found in two locations in southern China. According to Pu & al. (2019), a male specimen of *P.*

Figure 3. *Platycnemis phasmovolans*. (A-B) Kaew Neua Pass, Laos, 6 May 2016. Photo credit: Naoto Yokoi. (A) A mature male. (B) A mating pair. (C) Male, Maolan Nature Reserve, Guizhou, China, 2 July 2009. Photo credit: Hongbo Lan.

phasmovolans was photographed in the Maolan Nature Reserve in Libo County, in the southern part of Guizhou on 2 July 2009. Dr Xin Yu kindly sent me this photo (Fig. 3C) taken by Mr Hongbo Lan. The photo is also available on Yu's website [Link].

According to Xin Yu (*in litt.*), a male specimen of *P. phasmovolans* was also photographed by an insect hobbyist near Nanning in the southern part of Guangxi on 16 May 2018. Neither of the two male specimens photographed in China were collected, but their identity is not in doubt.

These two records made ca 600 and 800 km north-northeast of the site in Laos, indicate that the range of this species undoubtedly also includes northern Vietnam. The paucity of records in the species' range suggests that *phasmovolans* is rare, elusive and local. Being apparently a rainy season species, possibly confined to stream habitats in densely forested habitats, it is presumably seldom encountered.

Unusually dilated tibiae in Platycnemididae

Platycnemis phasmovolans is of the same size as most of its congeners (the total length of males is 37–38 mm and the hind wing length 19 mm), but the enormously expanded tibiae in the middle and hind legs in male make it extraordinary. The hind tibia is about 5.5 mm long and maximally about 2.0 mm wide. In fully mature males the tibiae are pure white (Figs 3 & 4A-C), but in younger males the tibiae are pinkish (Fig. 1B). As seen from the photoshopped image (Fig. 4C), the size of the hind tibiae of the holotype nearly equals in size the whole thorax of the specimen. As in all its congeners, the female of *P. phasmovolans* has normal tibiae.

Several other platycnemidid species have expanded middle and hind tibiae. However, in none of these is the dilation as extreme as in *P. phasmovolans*. The nearest competitor, in terms of relative tibial breadth is *Proplatycnemis alatipes* (McLachlan, 1870), a rare species from Madagascar (Fig. 4D). The eastern Palaearctic species, *Platycnemis foliacea* Selys, 1886 (Fig. 4E) and *P. phyllopoda* Djakonov, 1926 (Fig. 4F) also have strongly dilated tibiae.

Recently, an extraordinary fossil platycnemidid species – *Yijenplatycnemis huangi* – was described from the mid-Cretaceous Burmese amber, dating back to ca 99 MYA by Zheng & al. (2017). Although this species is distinctly smaller than *P. phasmovolans*, its tibiae are longer and relatively much wider (Fig. 5). In *Y. huangi*, the length of the hind tibiae is 6.63 mm (ca 5.5 mm in *P. phasmovolans*) and its maximum breath is 2.96 mm (ca

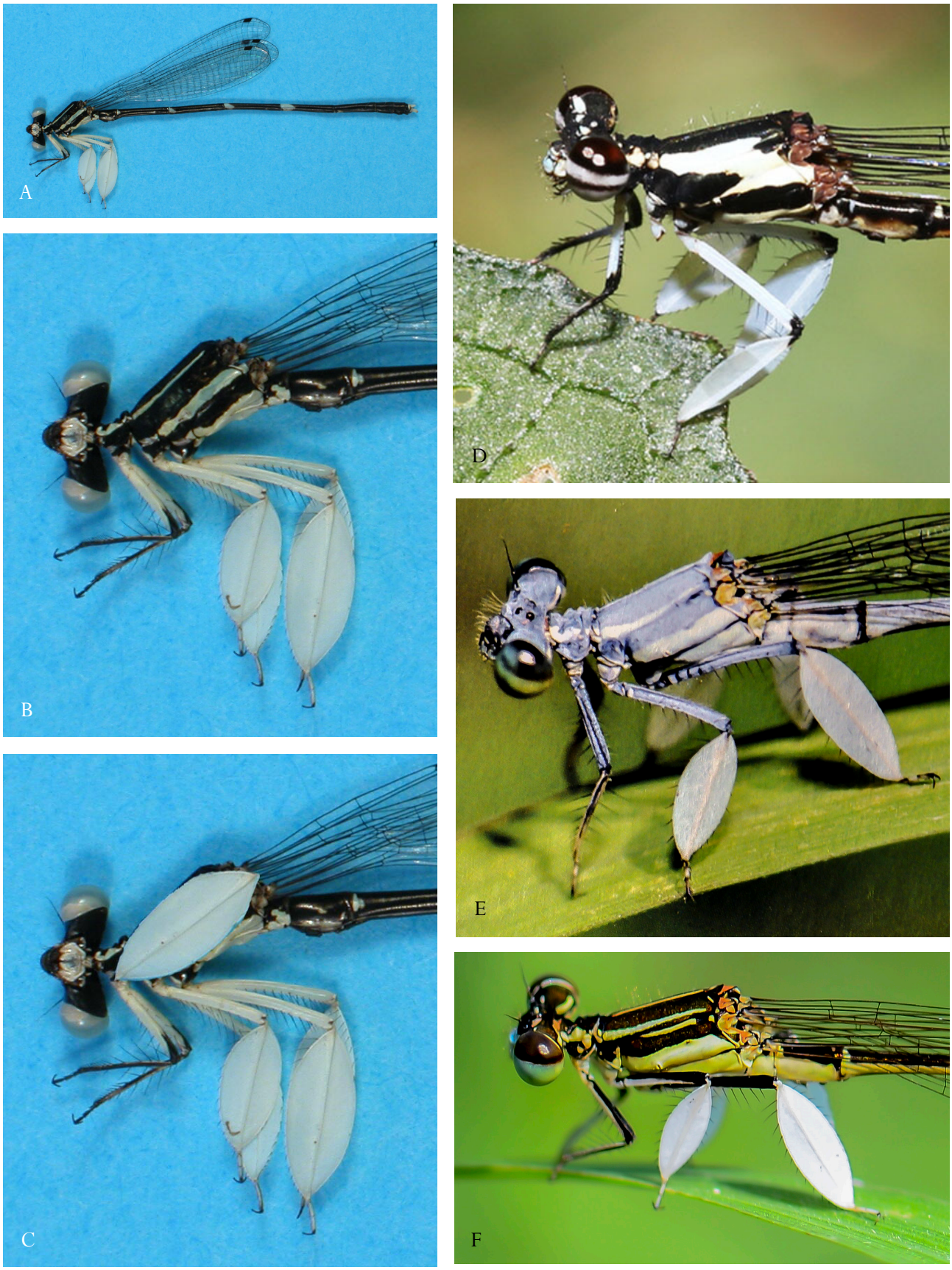

Figure 4. Cropped images, not in scale. (A-C) Holotype male *Platycnemis phasmovolans*, collected in Laos on 29 April 2002. Photo credits: Matti Hämäläinen. (A) Lateral view. (B) Head, thorax and legs, lateral. (C) An image showing the size of the hind tibia relative to thorax. (D) *Proplatycnemis alatipes* from Madagascar. Photo credit: Callan Cohen. (E) *Platycnemis foliacea* from China. Photo credit: Haomiao Zhang. (F) *Platycnemis phyllopoda* from China. Photo credit: Haomiao Zhang.

2.0 mm in *P. phasmovolans*). In contrast with all extant platycnemidid species, in *Y. huangi* the fore tibiae are also dilated, although not so much as the hind pair.

As the title of the article by Zheng & al. (2017) suggests, the authors speculate that the wide tibiae may have had a role in the courtship behaviour in this fossil species. They wrote: "Within recent damselflies, male *Platycypha* [Chlorocyphidae] and *Platycnemis* species have expanded tibiae used for courtship displays." However, although in modern platycnemidids the tibiae may be briefly involved in in-tandem courtship (Buchholtz, 1956), their most obvious use is in brief agonistic frontal displays by rival males waiting to mate with females. During the threat display the tibiae are turned to face the antagonist and quivered (e.g. Martens, 1996). There is a possibility the sight of fighting males may attract females, in which case the display might qualify as a 'dual' display, or mini lek, but this remains untested.

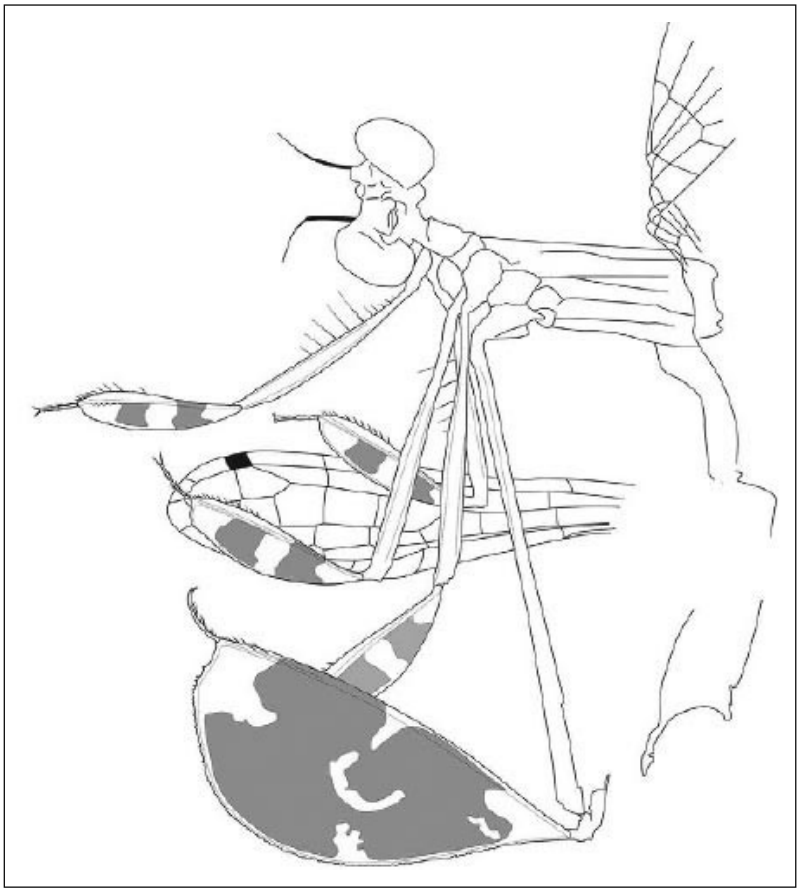

Figure 5. Drawing of the holotype of the fossil damselfly *Yijenplatycnemis huangi*, copied from Zheng & al. (2017) [Link].

Acknowledgements

Albert G. Orr improved the English expression of the manuscript, proposed additions to the text on the behaviour of platycnemidids and offered other valuable help, including processing images. Naoto Yokoi informed on his unpublished new record in Laos and gave his excellent photographs for my use. Xin Yu gave detailed information on the Chinese records of *P. phasmovolans* and sent the photograph taken by Hongpo Lan. Haomiao Zhang let me use photographs of two *Platycnemis* species from China. Klaas-Douwe B. Dijkstra gave information on the Malagasy species of *Proplatycnemis* and sent the photograph of *P. alatipes,* taken by Callan Cohen. I am grateful to them all for their kind assistance.

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Swift action by Edmond de Selys Longchamps in describing two exciting new 'living fossil' odonate species *Hemiphlebia mirabilis* and *Epiophlebia superstes*

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In our hectic, permanently online world, it is common for enthusiastic naturalists and dragonfly photographers to distribute their observations and images via various social media channels very soon after they are made, sometimes even within a few minutes directly from the field.

In the latter half of the 19th century, communications were slow, and the dissemination of scientific results was often unreliable. However, even in those days, when an entomologist got hold of something really special, he (or very rarely she) could on occasion act quickly. Here I present details of two remarkably rapid dragonfly species descriptions published by Edmond de Selys Longchamps.

The marvellous *Hemiphlebia mirabilis* Selys, 1868

On the 26th of February 1868 Edmond de Selys Longchamps wrote in his diary (see Caulier-Mathy & Haesenne-Peremans, 2008): "*Achever d' étaler les Agrions en alcool de la Nouvelle-Hollande de M. Weyers*" [Finished spreading the damselflies in alcohol from New Holland from Mr Weyers]". These specimens from Australia included four damselfly species. Among them was a series of over twenty male and female specimens of a peculiar, tiny species, which excited Selys greatly. He quickly completed a brief manuscript erecting the new genus *Hemiphlebia* and describing its type species *H. mirabilis*. He presented this paper at the meeting of the *Sociéte entomologique de Belgique* at Brussels on the 7th of March 1868, only ten days after finishing spreading the specimens in question for study. In the beginning of the two page note (Selys Longchamps, 1868a) the author promises to publish a more extensive account of the same subject in a forthcoming volume of the annals of the society. [This was completed nine years later, see Selys Longchamps (1877)].

Selys was in such a hurry to announce this new species – *cet Odonate extraordinaire* – that he did not wait to complete his description of another remarkable damselfly from Weyers' material. This other novelty, *Synlestes weyersii* – also a new genus and species – was described in a manuscript presented in the following meeting of the society on 4th of April 1868. The description was based on a single incomplete female specimen (with its abdomen tip missing). In the same communication (Selys Longchamps, 1868b) he also described a new species of Mecoptera, *Bittacus nigriceps* (presently *Harpobittacus nigriceps*), based on a large number of specimens received from Weyers.

In his description of *Synlestes weyersii*, Selys praised the eponymee as follows: "*… donnée par M.Weyers, auquel je suis heureux de témoigner ici ma reconnaissance pour les services que par ses relations étendues il rend à l'Entomologie.*" [… donated by Mr Weyers to whom I am happy to affirm here my recognition for the services which he, by his extensive connections, renders to entomology.] That Selys honoured Weyers so fulsomely with this eponym was surely a mark of gratitude for his having provided Selys with the *Hemiphlebia* specimens rather than the *Synlestes* specimen. Undeniably, the unique and 'miraculous' *Hemiphlebia* species (Fig. 1) deserved a much more arresting epithet than '*weyersii*'.

Joseph Leopold Weyers (d. 1908) was a Belgian engineer and industrialist from Brussels. He was a keen malacologist and entomologist. His main entomological interest was in the jewel beetles (Buprestidae), of which Australia has a particularly rich fauna. In the 1860s he was the secretary and librarian of the *Sociéte Entomologique de Belgique*, and therefore in regular contact with Selys, who was an active member of the society and its first president from 1855 to 1858. (Selys was also appointed as the Honorary President in 1880 and in 1884 he served a second term as President).

Weyers had received the Odonata and Mecoptera specimens from collectors from Australia. The type locality given for the specimens 'Port Denison' (= Bowen) in north Queensland is incorrect; they apparently originated from Victoria.

Figure 1. Male of *Hemiphlebia mirabilis*. Long Swamp, Discovery Bay, Victoria, Australia, 3 December 2013. Photo credit: Adolfo Cordera Rivera.

However, 'Port Denison' does not refer to Lake Denison in Victoria, as is sometimes thought (see Theischinger & Endersby 2009).

Between 1884 and 1898, Weyers was based as an engineer for a total of 14 years (on two separate occasions) in Sumatra. When possible, he collected molluscs and insects, mainly buprestids. He discovered numerous new species, several of them now bearing the species epithet *weyersi*. Later, in 1899–1900 Weyers worked in Sambas, in the western part of Borneo, for eight and half months. In Sumatra Weyers collected dragonflies for Selys. His early packages included the holotype of the coenagrionid species *Amphicnemis ecornuta* Selys, 1889. In March and November 1898 Selys received from Weyers a total of nearly 200 specimens from Sumatra, but unfortunately, he did not publish on this material as it reached him near the end of his life.

Correctly referring to these two brief papers of Selys, published in the '*Comptes-rendus de la Société Entomologique de Belgique*', which falls under the aegis of the journal *Annales de la Société Entomologique de Belgique*, has caused headaches for many later authors and cataloguers, partly because the two separate communications are also available as a single reprint of four pages (numbered 1–4), titled *Note sur quelques Nevroptères nouveaux de Port Denison (Australie)*. The titles presented in the reference list below are identical to those presented on page CXIV of the volume where the articles were published, see link.

Although Selys acted quickly, the spread of the news of *Hemiphlebia mirabilis*, beyond the few people who had attended the society's meeting in March, was slower. Since the publication includes papers presented at a meeting on 1st August 1868, it was published, at the earliest, in August 1868, but certainly in the year 1868[1]. As far as I know, separate 'Compte-rendu' issues of individual meetings were not published at that time (cf. Selys' description of *Palaeophlebia superstes*, on page 92).

Later, on the 15th of July 1876, Selys executed a watercolour drawing of the *Hemiphlebia mirabilis* specimens. His portfolio also includes two sets of ink drawings of the wings and venational details of this species (Fig. 2). It is not known when he did the ink drawings, but obviously they were produced to facilitate the detailed description published in 1877.

Epiophlebia superstes (Selys, 1889) – the primitive survivor

On the 1st of May 1889 Selys received something even more unique than *H. mirabilis*. His diary entry of that day reads: "*Arrivée de quinze boîtes du Japon, collection de feu M. Pryer*." [Arrival of fifteen boxes from Japan, the collection of the late Mr Pryer.] For the next five days he was busy with identifying the material. On the 3rd of May he wrote: "*Dépiqué et classé les odonates, trois cent cinquante-deux en soixante espèces*." [Picked out and classified the odonates, 352 specimens in 60 species.]. Next day he wrote: "*Classé les odonates et déterminé les espèces*." [Classified the odonates and determined the species.] and on the 5th May: "*Achevé les Agrions Pryer, classé les non-odonates, sept cent soixate-deux exemplaires*." [Finished Pryer's Agrions, classified the non-odonates, 762 specimens]. These specimens were collected or acquired by the late Henry Pryer, who had resided in Japan for about 17 years (see below). Pryer's material was sent to Selys by Oliver Erichson Janson (1850–1926) of London, co-proprietor of Janson and Son, Pryer's agent in zoological matters.

The specimens included one male and one female of an extraordinary new species collected in Gifu (in the central part of Honshu) on the 1st of May 1886.[2] Selys correctly surmised that the species represented a kind of a 'living fossil' and he rushed to describe it, giving it the name *Palaeophlebia superstes*. The Greek suffix 'Palaeo' means 'ancient' or 'primitive' and the Latin species epithet superstes means 'surviving'. In his classification Selys included the species in a new legion of his 'sous-famille Caloptérygines'.

Selys considered this species (Fig. 3) so unique that he decided to include a colour plate to complement his description (this was exceptional, since very few of Selys' descriptions were illustrated). Therefore, on the 12th of May he asked Guillaume Séverin (1862–1938), a young entomologist and skilful illustrator from Liège, to make coloured drawings of the new species.

Séverin and Selys met several times during the next two months, suggesting that Selys followed Séverin's progress closely. His diary entry of the 14th of July reads: "*M. Séverin me rapporte les dessus de Palaeophlebia superstes Selys de la collection Pryer.*" [Mr Séverin brought me the drawings of *Palaeophlebia superstes* Selys from the Pryer collection.] On the 27th of July, Séverin visited Selys again in Liège.

Probably, Selys' manuscript describing this species was already finished by that time, but he could not submit it at the next meeting of the *Sociéte Entomologique de Belgique* in Brussels on the 3rd of August, since that same day he left for a two week visit to Paris. Finally, on the 7th of September 1889 Selys had a chance to present the paper at the meeting of the society. The article was titled: "*Palaeophlebia nouvelle légion de Caloptérygines, suivi de la description d'une nouvelle Gomphine du Japon: Tachopteryx pryeri*" (Selys Longchamps, 1889a).

Correct referencing of Selys' paper is not straightforward. The report of the communications, including

1 In many publications and checklists of the World Odonata, the authorship of *H. mirabilis* is given as 'Selys, 1869'. The error, which first appeared in Kirby's (1890) catalogue, is due to the fact that the contents of volume 11 of the *Annales* were not indexed in the 'Zoological record' of 1868, and appeared first in the 1869 issue.

2 According to Asahina (1986) the collecting date on labels attached to the specimens at IRSN (Brussels) is 27 April 1886.

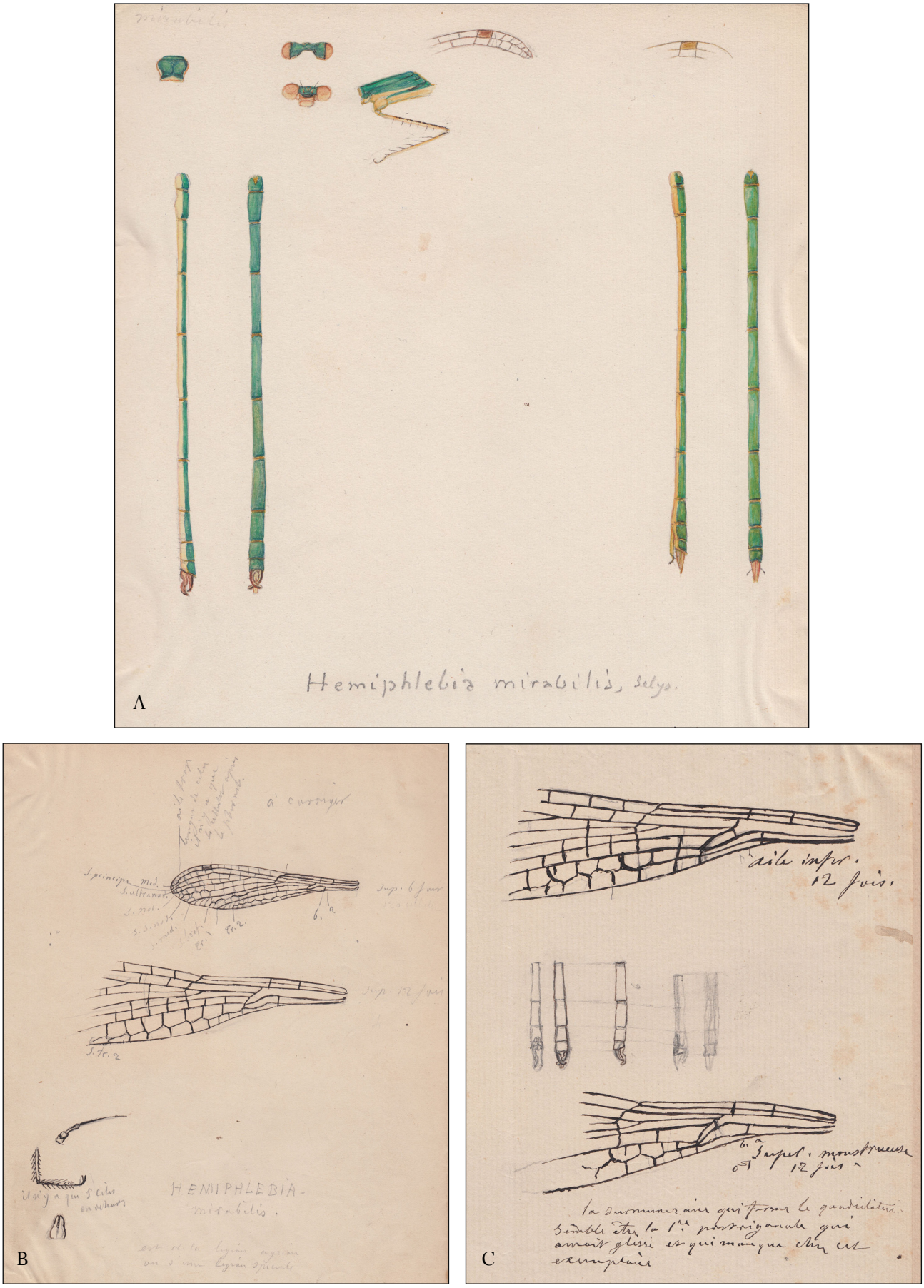

Figure 2 (A-C). Illustrations of *Hemiphlebia mirabilis*, executed by Edmond de Selys Longchamps. The watercolour plate is dated Liège, 15 July 1876. The ink drawings are undated. By courtesy of the Royal Belgian Institute of Natural Sciences, Brussels.

Selys' article, presented in the society's meeting on the 7th of September, was first published for public sale as a separate issue of 12 pages (excluding covers), with the pagination cliii–clxiv. In the front cover of the issue (Fig. 4), the title of the publication is given as: *Société Entomologique de Belgique, Compte-rendu Séance du 7 septembre 1889*. This publication has the same content and pagination as the corresponding 'Comptes-Rendus' issue annexed to the volume 33 of *Annales de la Société Entomologique de Belgique*, published later. However, this 'pre-publication' does not include the colour plate of *Palaeophlebia superstes*, but it includes the figure legends of the plate, with a footnote stating that the plate (Fig. 5) will be published in the *Annales*. In any case, Selys' descriptions of the new species were validly published in this issue, probably in September 1889. The reprint of Selys' article (Fig. 6) includes the colour plate and seven text pages, numbered 1–7. On the reverse side of the cover is an addition to the article titled, '*Note additionnelle sur la disposition des deux secteurs de l'arculus chez le genre Palaeophlebia*'. As far as I know, Selys did not publish this note in any journal.

In the meeting of the Académie Royale des Sciences de Belgique, on the 9th of November 1889, Selys presented a note on his two latest major publications. Referring to his *Palaeophlebia* paper, he stated (translated): "The discovery of *Palaeophlebia* seems to me to offer much interest, because this new genus appears to belong to a group *Heterophlebia* of Westwood [in fact Brodie, 1849], which was until now known only from fossil forms from the secondary grounds (Lias of England and lithographic shales of Baviere) and also the tertiary lignites from the Rhine." (Selys Longchamps, 1889b). Presumably, Selys' close collaborator Hermann A. Hagen (1817–1893) had alerted him to this relationship. Hagen himself had named fossil species in this genus.

Subsequently Calvert (1903) pointed out that Selys' genus name *Palaeophlebia* was preoccupied by Friedrich Brauer's genus name *Palaeophlebia* given to a fossil odonate genus in March 1889 (Brauer & al. 1889). Therefore, he introduced the replacement name *Epiophlebia*.

Selys' paper also included the description of a very interesting new species dedicated to the late Henry Pryer – the petalurid *Tachopteryx pryeri*, presently known as *Tanypteryx pryeri*. It is the only Asian representative of this small relic family, perhaps the most ancient of the extant Odonata, with about ten species ranging from Australia and New Zealand to Chile, North America and Japan. This species was also represented by one male and one female in Pryer's material, both collected in Gifu on the 10th of May 1886. Earlier, Pryer had sent odonate specimens to Robert McLachlan (1837–1904). McLachlan, in turn, had provided examples to Selys for his regional monograph '*Les Odonates du Japon*'

Figure 3. Female of *Epiophlebia superstes* laying eggs. Kaizuka-shi, Osaka Prefecture, Japan, May 2006. Photo credit: Tetsuo Yamamoto.

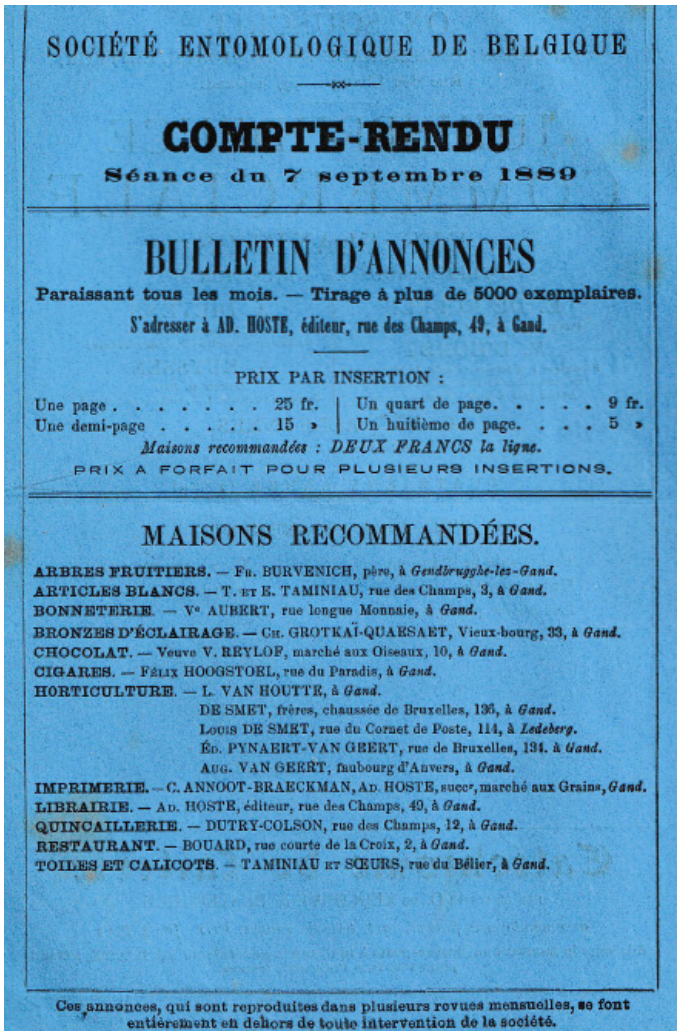

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Figure 4. Front cover of the Compte-Rendu issue, where Selys' 1889 paper was first published for sale, apparently in September 1889. Photo credit: Akihiko Sasamoto.

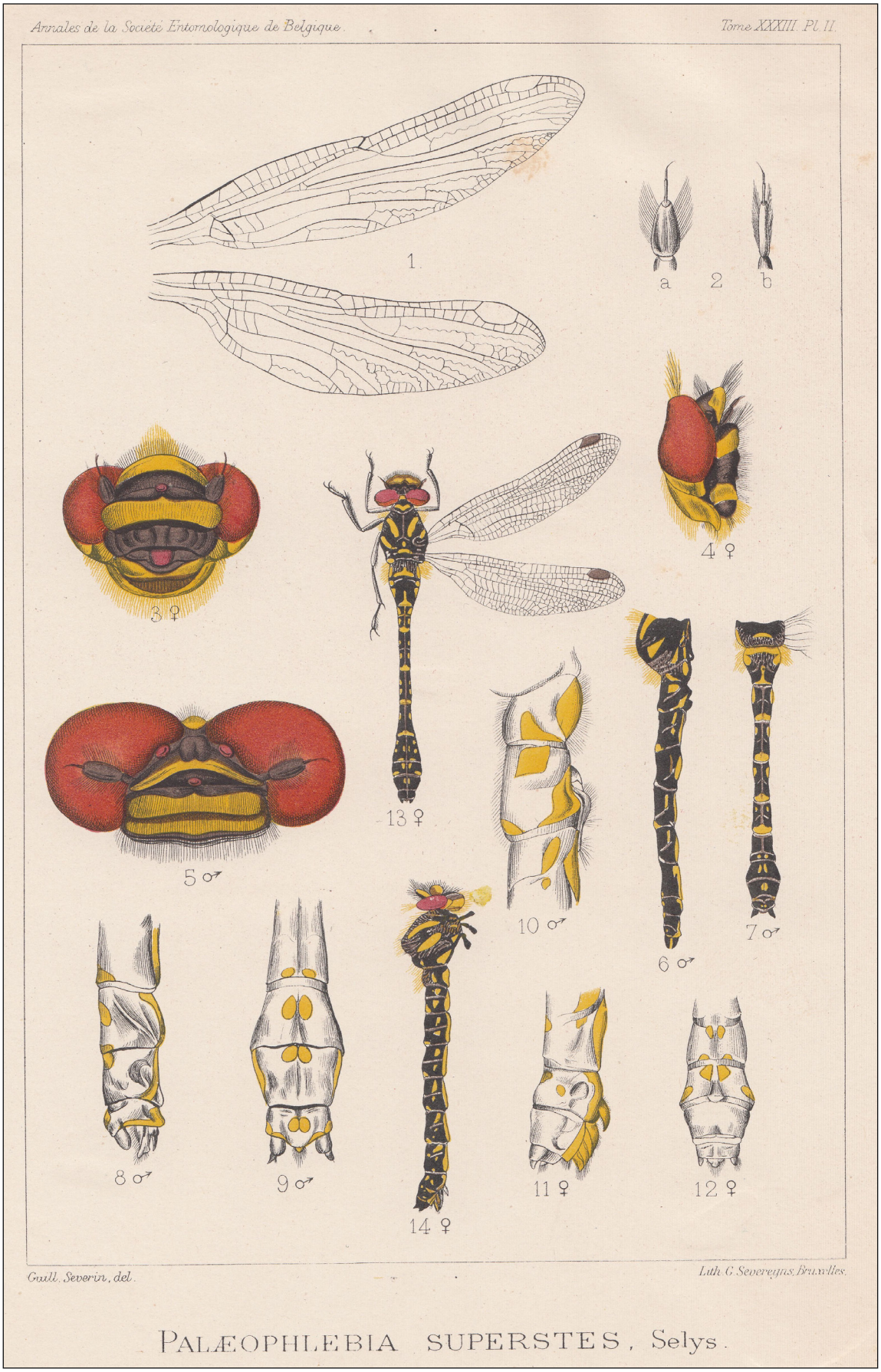
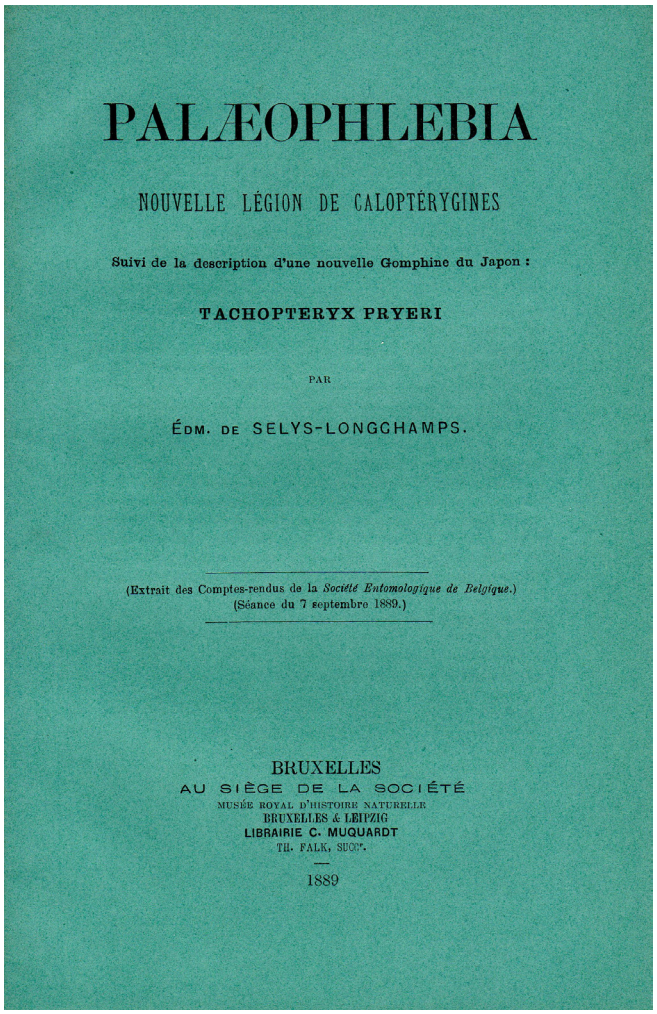


Figure 5. The colour plate by Guillaume Séverin, illustrating male and female of *Epiophlebia superstes*. The plate was published in the paper by Selys Longchamps (1889a). By courtesy of the Royal Belgian Institute of Natural Sciences, Brussels.

(Selys Longchamps 1883). Another of the numerous new species in this publication was named after Pryer as *Gomphus pryeri*, presently known as *Asiagomphus pryeri*. The single female specimen was collected in Yokohama.

It is obvious that Pryer did not himself collect the specimens of *Epiophlebia superstes* and *Tanypteryx pryeri*. Esaki (1935) lists localities where Pryer collected; neither Gifu City nor Gifu Prefecture (the latter was earlier called Mino Province) are among them. According to Asahina (1986), it is likely that Pryer had received the *Epiophlebia* specimens from Yasushi Nawa (1857–1926), the future director of the Nawa Entomological Laboratory at Gifu. Nawa and Pryer are known to have been in contact and they also exchanged specimens. However, Asahina concluded that it is not clear if Nawa himself collected the specimens. Since the *Tanypteryx* specimens were labelled as being collected in Gifu less than two weeks after the *Epiophlebia* specimens, it seems obvious to me that both were in the same lot received from Nawa.


PALÆOPHLEBIA

NOUVELLE LÉGION DE CALOPTÉRYGINES

Suivi de la description d'une nouvelle Gomphine du Japon :

TACHOPTERYX PRYERI

PAR

ÉDM. DE SELYS-LONGCHAMPS.

(Extrait des Comptes-rendus de la *Société Entomologique de Belgique*.)
(Séance du 7 septembre 1889.)

BRUXELLES
AU SIÈGE DE LA SOCIÉTÉ
MUSÉE ROYAL D'HISTOIRE NATURELLE
BRUXELLES & LEIPZIG
LIBRAIRIE C. MUQUARDT
TH. FALK, SUCC^R.
1889

Figure 6. Front cover of the reprint of the paper by Selys Longchamps (1889a). Photo credit: Matti Hämäläinen.

Henry James Stovin Pryer was born in London, the son of a lawyer, on 10th June 1850. He died of pneumonia in Yokohama on 17th February 1888. He was an amateur English entomologist and ornithologist. Following his older brother William Burgess Pryer (1843–1899), who went to work in Shanghai in 1865, Henry Pryer travelled to China in 1871. However, later the same year he moved to Japan, where he remained for the rest of his life. His plans for a home visit to England in 1888 or 1889 did not eventuate. After arriving in Japan, he first worked in a foreign trading house in Yokohama. In 1877 he was engaged for a short period with the Government Natural History Museum in Tokyo, but was thereafter again engaged in mercantile pursuits. His last occupation was in the service of Bisset & Co., headed by James Bisset (1841–1911), himself also a keen naturalist and amateur botanist. Pryer travelled throughout Japan, including the Loo-Choo islands [the Ryukyus] and Bonin [Ogasawara] islands, and collected insects (especially butterflies) and birds. He also engaged Japanese collectors to provide him with specimens. In 1884 he visited Sandakan in the British North Borneo, where his older brother W.B. Pryer, 'the Founder of Sandakan', and also a recognized naturalist, was based at that time.

Pryer published biological observations on Japanese butterflies and wrote and illustrated a bilingual (English and Japanese) work '*Rhopalocera Nihonica*: A description of the butterflies of Japan', which was issued in three separate slender volumes from 1886–1889, two of them appearing after Pryer's death (Pryer, 1886, 1888, 1889). The publication includes brief accounts of 137 species and is illustrated with ten fine colour plates. He also co-authored several annotated lists of Japanese birds with Thomas Wright Blakiston (1832–1891). Among the new bird species he discovered is the Marsh Grassbird, *Locustella pryeri* (Seebohm, 1884). It was said that his genial and kind nature made him very popular among the Japanese and the European diaspora in Japan.

A modern perspective

It is notable that Selys' deep understanding of the Odonata allowed him to immediately recognize just how special *Hemiphlebia mirabilis* and *Epiophlebia superstes* were, and this clearly spurred him to expedite their publication.

Both species represent the last surviving members of ancient, formerly widespread families. The extant species have very limited relic distributions. At present, the family Hemiphlebiidae is placed in the superfamily Lestoidea, where it is the sister group of all other families. Several fossil hemiphlebiid species from the Cretaceous period have been found in various parts of the world. Particularly fine examples are present in the Crato deposits of Brazil, dating to the lower Cretaceous ca 113 MYA (Martill & al, 2007), and recently, mid-Cretaceous specimens of two hemiphlebiid species have been found in Burmese amber (Zheng & Wang, 2019).

The closest known fossil relative of the present *Epiophlebia* species is *Burmaphlebia reifi* Bechly & Poinar, 2013, placed in the new family Burmaphlebiidae in the superfamily Epiophleboidea. It too was found in Burmese amber dating to the early Cretaceous (Bechly & Poinar, 2013). Numerous more distantly related, or possibly unrelated 'Anisozygoptera' fossils from the Mesozoic have been recorded worldwide.

Selys' placement of the genus *Epiophlebia* (in a new 'Légion Palaeophlebia') within the calopterygoid damselflies (Selys Longchamps, 1889a) must be understood in terms of prevailing knowledge; it was surely no worse than Robin John Tillyard's (1881–1937) initial placement of the genus (as a subfamily Epiophlebiinae) in the zygopteran family Lestidae (Tillyard, 1917: 276). After studying a larva of *Epiophlebia*, Tillyard (1921) transferred the genus to the suborder Anisozygoptera Handlirsch, 1906. It should be noted that Handlirsch (1906: 463–465) had already included *Epiophlebia superstes* in this suborder along with several fossil taxa, and Tillyard, who was interested in fossil forms, was surely aware of this. It is now widely accepted that the family Epiophlebiidae and Anisoptera are both monophyletic sister groups.

Acknowledgements

Albert G. Orr improved the English expression of the manuscript and offered valuable comments, including suggesting that the fossil record of related taxa be discussed. Akihiko Sasamoto provided translations on some Japanese publications regarding Henry Pryer and *Epiophlebia superstes*. He also provided valuable information on the first publication of Selys' 1889 paper. Adolfo Cordera Rivera and Tetsuo Yamamoto permitted me to include their superb photos of *Hemiphlebia mirabilis* and *Epiophlebia superstes*, respectively. Karin Verspui sent scans of Selys' illustrations of *H. mirabilis* and *E. superstes*. I am grateful to them all for their kind assistance.

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Eight new additional records of Odonata from Bhutan

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Abstract. Findings of the Odonata expedition made between 20-v-2017 and 9-vi-2017 in the eastern districts of Bhutan are presented. Additional collections made by the author are also reported. Eight species: *Anisopleura* sp, *Bayadera longicauda, Agriocnemis lacteola, Ceriagrion azureum, Nychogomphus duaricus, Idionyx stevensi*, *Sympetrum haematoneura* and *Tramea limbata* are new records for Bhutan.

Key words. Odonata, eastern Bhutan, records, Bhutan Trust Fund for Environmental Conservation (BTFEC), dragonfly

Introduction

In 2014, Bhutan Trust Fund for Environmental Conservation (BTFEC) granted funding support to National Biodiversity Center of Bhutan for improving the knowledge database of invertebrates in Bhutan. This resulted in the Bhutan Invertebrate Biodiversity Project for the period of three years, 2014-2016. Odonata was one of the five invertebrate groups identified for the study. The National Biodiversity Centre of Bhutan signed a Memorandum of Understanding with Naturalis Biodiversity Center of the Netherlands for scientific cooperation. Following this, several joint Odonata expeditions were carried out in 2014, 2015 and 2016 resulting in the discovery of 26 species new to the country including one species (*Megalestes gyalsey* Gyeltshen, Kalkman & Orr, 2017) new to science (Gyeltshen at. al., 2016; Kalkman & Gyeltshen, 2016; Gyeltshen 2017; Gyeltshen, Kalkman & Orr, 2017 and Gyeltshen & Kalkman, 2017). Nonetheless many regions remained inadequately explored and more expeditions were felt necessary. Therefore, a joint expedition by Jan van Tol from Naturalis and the author was conducted in the five eastern districts of Bhutan in May and June, 2017.

Following the expedition several additional sites were visited by the author. The findings from the expedition and the additional collections are presented in this report. In addition, *Ceriagrion azureum*, recorded during a survey in 2015, is here also reported.

Method

Fieldwork was carried out between 20-v-2017 and 9-vi-2017 in the eastern districts of Mongar, Tashi Yangtse, Tashigang, Samdrupjongkhar and Pemagatshel (Fig. 1). In total, 37 localities were visited. After the expedition, locality 25 was visited a second time (10-ix-2017). Localities 38 (2-iv-2017) and 39 (11-v-2015) were not visited during the expedition and were visited on different occasions. The specimens were identified using the identification keys of Fraser (1933, 1934, and 1936). The collected specimens were deposited in the repository centre at National Biodiversity Centre of Bhutan.

List of localities visited

(1) Trashiyangtse District, Bumdelling, a small roadside stream (27.63599N, 91.47926E, 1827 m a.s.l), 20-v-2017. **(2)** Trashiyangtse District, Bumdelling, an acorus pool (27.6584N, 91.45360E, 1889 m a.s.l), 20-v-2017. **(3)** Trashiyangtse District, Bumdelling, a polygonum pool (27.65861N, 91.45306E, 1885 m a.s.l), 20-v-2017. **(4)** Trashiyangtse District, Bumdelling, a small stream (27.66375N, 91.43344E), 21-v-2017. **(5)** Trashiyangtse District, Bumdelling, a vegetated rivulet (27.66298N, 91.43465E), 21-v-2017. **(6)** Trashiyangtse District, Baeling, a small stream (27.62871N, 91.49904E, 2026 m a.s.l), 22-v-2017. **(7)** Trashiyangtse District, Baeling, a rivulet with vegetated banks (27.61759N, 91.50121E, 1887 m a.s.l), 22-v-2017. **(8)** Trashiyangtse District, Ranja, a rivulet with vegetated banks (27.55378N, 91.52024E), 22-v-2017. **(9)** Trashiyangtse District, Doksum, a small riverside swamp with shallow pools (27.43534N, 91.57862E, 848 m a.s.l), 23-v-2017. **(10)** Samdrupjongkhar District, Phuntshogthang, at light next to hotel (26.88499N, 91.68734E, 349 m a.s.l), 24-v-2017. **(11)** Samdrupjongkhar District, Phuntshogthang, a small roadside stream (26.91874N, 91.68080E, 368 m a.s.l), 25-v-2017 and 28-v-2017. **(12)** Samdrupjongkhar District, Way to Martsala, a very small and narrow brook (26.2693985N, 91.67635E, 709 m a.s.l), 25-v-2017. **(13)** Samdrupjongkhar District, Phuntshogthang, a large roadside stream (26.92845N, 91.67451E, 353 m a.s.l), 26-v-2017. **(14)** Samdrupjongkhar District, Phuntshogthang, a small steep and shaded stream (26.93215N, 91.67170E, 353 m a.s.l), 26-v-2017. **(15)** Samdrupjongkhar District, Warongkhola, a rivulet with vegetated banks (26.89033N 91.72158E, 389 m a.s.l), 26-v-2017 and 28-v-2017. **(16)** Samdrupjongkhar District, Pemathang, a small stream among agriculture fields (26.89075N, 91.73811E,

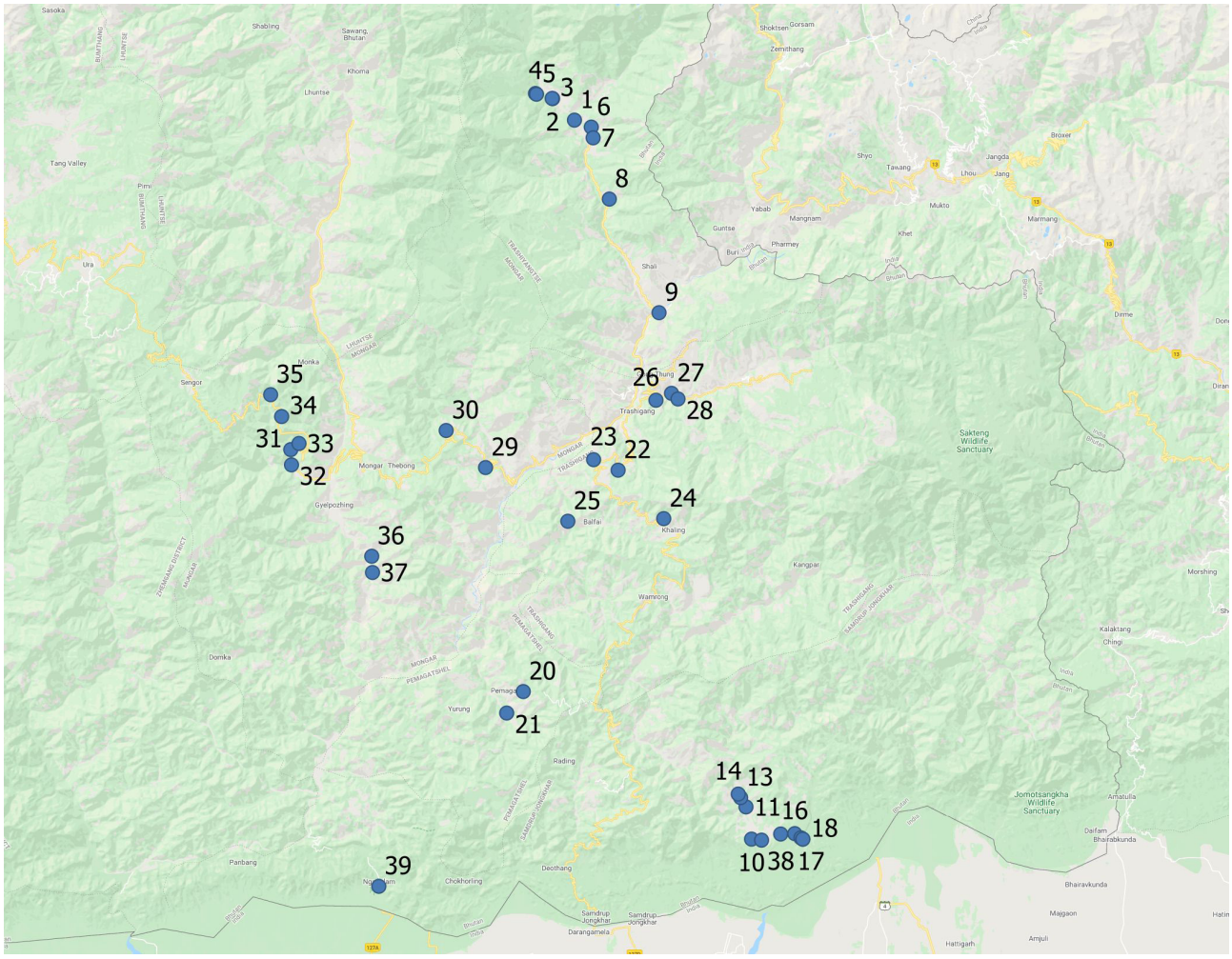

Figure 1. Map showing localities. All of them are in the east of Bhutan in the districts of Mongar, Tashi Yangtse, Tashigang, Samdrupjongkhar and Pemagatshel.

399 m a.s.l), 26-v-2017. **(17)** Samdrupjongkhar District, Pemathang, a brook in a steep valley before outlet into large river (26.8863N, 91.74529E, 326 m a.s.l), 27-v-2017. **(18)** Samdrupjongkhar District, Pemathang, a source and small brook (26.88495N, 91.74757E, 337 m a.s.l), 27-v-2017. **(19)** Samdrupjongkhar District, Martsala, a small steep brook and a small roadside spring (26.88495N, 91.74757E, 750 m a.s.l), 27-v-2017. **(20)** Pemagatshel District, Denchi, a small brook (27.03950N, 91.41912E, 1371 m a.s.l), 30-v-2017. **(21)** Pemagatshel District, Denchi, river (27.01703N, 91.399645E, 670 m a.s.l), 30-v-2017. **(22)** Tashigang District, Rongthong, a small seeping area next to a larger brook (27.27100N, 91.53055E, 1870 m a.s.l), 3-vi-2017. **(23)** Tashigang District, Pangthang, a small seeping and trickling spring (27.28196N, 91.50176E, 1844 m a.s.l), 3-vi-2017. **(24)** Tashigang District, Gomchu, a stream with vegetated banks (27.22036N, 91.58417E, 1705 m a.s.l), 4-vi-2017. **(25)** Tashigang District, Chhiya, a pond above agricultural area (27.21763N, 91.47149E, 1999 m a.s.l), 4-vi-2017, 10-ix-2017. **(26)** Tashigang District, Reju, a small stream in disturbed environment (27.34403N, 91.57504E, 868 m a.s.l), 5-vi-2017. **(27)** Tashigang District, Godi, a small stream with vegetation cover (27.35122N, 91.59331E, 850 m a.s.l), 5-vi-2017. **(28)** Tashigang District, Godi, a small spring above road and seepage and swampy site below road near the bank of large river (27.34534N, 91.60090E, 834 m a.s.l), 5-vi-2017. **(29)** Mongar District, below Yadi, a stream in an open gorge (27.27371N, 91.37480E, 1077 m a.s.l), 6-vi-2017. **(30)** Mongar District, Yadi Ngatshang, a pond among agricultural area (27.31243N, 91.32852E, 1774 m a.s.l), 6-vi-2017. **(31)** Mongar District, Lingmethang, a small stream beside an agricultural area (27.29247N, 91.14594E, 931 m a.s.l), 7-vi-2017. **(32)** Mongar District, Lingmethang, an open large stream (27.27651N, 91.14679E, 746 m a.s.l), 7-vi-2017. **(33)** Mongar District, Thrinangbi, a small brook (27.29885N, 91.15559E, 1085 m a.s.l), 7-vi-2017. **(34)** Mongar District, Phrumshingla National Park Yongkhola, a small shaded stream (27.32702N, 91.13520E, 1897 m a.s.l), 8-vi-2017. **(35)** Mongar District, Phrumshingla National Park Yongkhola, a small stony brook (27.34980N, 91.12230E, 2187 m a.s.l), 8-vi-2017. **(36)** Mongar District, South of Gyelposhing, a small brook in a narrow gorge (27.18106N, 91.24108E, 498 m a.s.l), 9-vi-2017. **(37)** Mongar District, South of Gyelposhing, a small stream with waterfall and pool (27.16406N, 91.24198E, 460

m a.s.l), 9-vi-2017. **(38)** Samdrupjongkhar District, Phuntshothang, an abandoned paddy field below road and with lowlying grasses near a drying up pond (26.8839N, 91.6991E, 345 m a.s.l), 2-iv-2017. **(39)** Pemagatshel District, Nganglam, a pond next to a school (26.8355N & 91.2494E, 581m a.s.l), 11-v-2015.

Results

In total, 41 species were collected from 37 sampling sites. Two males of *Agriocnemis lacteola* were collected from location 38 from the additional visit. A male specimen of *Ceriagrion azureum* was collected in 2015 from location 39. *Agriocnemis lacteola*, *Ceriagrion azureum*, *Bayadera longicauda*, *Anisopleura* sp., *Nychogomphus duaricus*, *Tramea limbata, Idionyx stevensi*, and *Sympetrum haematoneura* are additions to the Odonata fauna in Bhutan. These records increase the number of Odonata species known from Bhutan to 118.

List of collected species

New taxa for Bhutan are marked with an asterisk (*****).

Synlestidae

1. *Megalestes irma* Fraser, 1926
(35) 3♂

Lestidae

2. *Indolestes cyaneus* (Selys, 1862)
(2) 1♂, 1 copula
3. *Lestes praemorsus* Laidlaw, 1920
(8) 1♂ (30) 2♂

Platystictidae

4. *Drepanosticta carmichaeli* (Laidlaw, 1915)
(16) 2♀ (18) 2♂ (37) 3♂, 2♀
5. *Protosticta himalaica* Laidlawi, 1917
(20) 1♂ (23) 1♂

Calopterygidae

6. *Caliphaea confusa* Hagen in Selys, 1859
(5) 1♂ (23) 1♂ (34) 1♂
7. *Neurobasis chinensis* Linnaeus, 1758
(16) 1♂
8. *Vestalis g. gracilis* (Rambur, 1842)
(17) 1♂

Chlorocyphidae

9. *Rhinocypha* (*Aristocypha*) *cuneata* Selys, 1853
(27) 1♂ (29) 1♂
10. *Rhinocypha (A.) quadrimaculata* Selys, 1853
(16) 1♂ (17) 1♂ (19) 1♂
11. *Rhinocypha* (*Paracypha*) *unimaculata* Selys, 1853
(22) 2♂ (27) 1♂

Euphaeidae

12. *Anisopleura comes* Hagen, 1880
(29) 1♂ (33) 2♂
13. *Anisopleura lestoides* Selys 1853
(32) 1♂
14. *Anisopleura* sp.*
(36) 3♂, 1♀
15. *Anisopleura subplatystyla* Fraser, 1927
(23) 1♂
16. *Bayadera indica* (Selys, 1853)
(27) 2♂, 1♀ (29) 2♂, 1♀ (32) 1♂
17. *Bayadera longicauda* Fraser, 1928*
(35) 3♂

Figure 2. *Bayadera longicauda*, male. Phrumshingla National Park, Mongar District, Bhutan (8-vi-2017). Photo credit: Thinley Gyeltshen.

18. *Euphaea ochracea* Selys, 1859
(16) 2♂, 1♀ (17) 2♂, 1♀

Philogangidae
19. *Philoganga montana* Hagen in Selys, 1859
(16) 1♂

Platycnemididae
20. *Calicnemia eximia* (Selys, 1863)
(16) 1♂, 1♀
21. *Calicnemia miniata* (Selys, 1886)
(16) 1♂ (37) 1♀
22. *Coeliccia svihleri* Asahina, 1970
(12) 1♂ (19) 4♂, 1♀
23. *Coeliccia* sp.
(20) 2♂, 2♀
24. *Copera vittata assamensis* Laidlaw, 1914
(12) 1♂ (18) 1♂

Coenagrionidae
25. *Aciagrion pallidum* Selys 1891
(36) 1♂
26. *Aciagrion olympicum* Laidlawi, 1919
(2) 2♂, 1♀, 1 copula (30) 1♂, 1 copula
27. *Agriocnemis lacteola* Selys, 1877*
(38) 2♂
28. *Ceriagrion azureum* (Selys, 1891)*
(39) 1♂
29. *Ceriagrion fallax* Ris, 1914
(2) 1♂, 1♀

Aeshnidae
30. *Anax nigrofasciatus nigrolineatus* Fraser, 1935
(16) 1♂ (30) 1♂

Gomphidae
31. *Anisogomphus occipitalis* Selys,1854
(32) 1♀ (33) 2♂ (36) 2♂ (37) 2♂
32. *Davidius zallorensis* Hagen in Selys, 1878
(5) 2♂ (9) 1♂ (35) 2♂
33. *Nychogomphus duaricus* (Fraser, 1926)*
(16) 2♂
34. *Perisogomphus stevensi* Laidlaw, 1922
(8) 1♀ (32) 1♀
35. *Scalmogomphus bistrigatus* (Hagen, 1854)
(22) 1♂ (29) 1♂ (33) 1♂ 2♀ (36) 1♂ (37) 1♂

Cordulegastridae
36. *Anotogaster nipalensis* (Selys, 1854)
(8) 1♂

Macromiidae
37. *Macromia moorei* Selys, 1874
(22) 1 larva

Synthemistidae
38. *Idionyx stevensi* Fraser, 1924*
(37) 2♂ 1♀

Figure 3. *Agriocnemis lacteola*, male. Phuntsothang, Samdrupjongkhar District, Bhutan (2-iv-2017). Photo credit:Tshering Nidup.

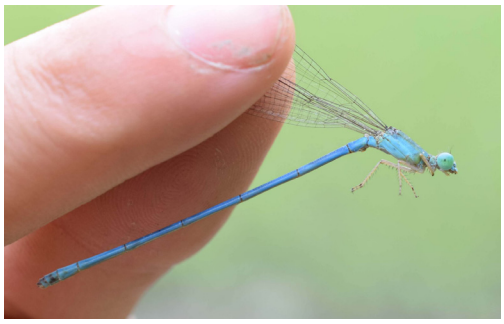

Figure 4. *Ceriagrion azureum*, male. Nganglam, Pemagatshel District, Bhutan (11-v-2015). Photo credit: Phurpa Dorji.

Libellulidae

39. *Acisoma p. panorpoides* Rambur, 1842
(10) 1♂

40. *Crocothemis s. servilia* (Drury, 1770)
(16) 1♂ (30) 1♂

41. *Lyriothemis bivittata* Rambur, 1842
(31) 1♀ (33) 1♀

42. *Sympetrum haematoneura* Fraser, 1926*
(25) 2♂

43. *Tramea limbata* (Desjardins, 1832)*
(25) 1♂, 1♀ (Copula)

Figure 5. *Sympetrum haematoneura*, male. Chhiya, Tashigang District, Bhutan (10-ix-2017). Photo credit: Tshering Nidup.

Discussion

The specimens of *Anisopleura* sp. collected at location 36 are close but not identical to *Anisopleura lestoides*. Further study is required to establish the species identity.

Bayadera longicauda was collected at location 35 at an altitude of 2187 m a.s.l (Fig. 2) which was surprising as the other species from the genus, *Bayadera indica*, occurs at far lower altitudes in Bhutan. However other records of *B. longicauda* are also of higher altitude with those from Nepal found between 1770-1890 m (Vick 1989) and those from Darjeeling, India between appr. 1600-2000 m (Fraser 1934). The site at location 35 from which the three males each of *Bayadera longicauda* and *Megalestes irma*, and a male *Davidius zallorensis* were collected is a well vegetated, shady and stony brook with a waterfall above the road and several smaller streams below the road (Fig. 6A).

The genus *Agriocnemis* Selys, 1869 contains some of the smallest odonates and occurs throughout the Oriental region and the tropical zones of Africa, Australia and Oceania. In total 45 species of *Agriocnemis* are known (Schorr & Paulson, 2017) but only two species viz. *A. clauseni* Fraser, 1922 and *A. femina* (Brauer, 1868) are known to occur in Bhutan (Mitra et. al., 2012; Kalkman & Gyeltshen, 2016). The record of *Agriocnemis lacteola* Selys, 1877, at location 38 is the third species of this genus to be found in Bhutan (Fig. 3). This small and creamy white species with black stripes was observed flying low among grasses at an abandoned paddy field next to a pond.

Ceriagrion azureum was collected in a field survey carried out in May, 2014 (Fig. 4). It was not previously reported from Bhutan and has therefore been included in this report. The Bhutanese record is from the surrounding region of Manas National Park.

Nychogomphus duaricus is a widely distributed species, its distribution covering Northern and Eastern India, Nepal, Sikkim, Bangladesh, Thailand, Lao DPR andPeninsular Malaysia (Subramanian, 2010). Its occurrence in the eastern region of Bhutan, therefore, comes as no surprise. The two males were caught at flight at

Figure 6. (A) Habitat of *Bayadera longicauda*, *Megalestes irma* and *Davidius zallorensis* collected, Phrumshingla National Park, Mongar District, Bhutan (8-vi-2017). (B) The pond at which *Sympetrum haematoneura* and *Tramea limbata* were sighted, Chhiya, Tashigang District, Bhutan (4-vi-2017). Photo credits: Thinley Gyeltshen.

dusk patrolling along the stream. Fraser reported *Onychogomphus duaricus* based on the collection made from Hasimara, Duars, India, which is only few kilometres distance from the boundary with Bhutan (Fraser, 1934). *Onychogomphus duaricus* is a robust flyer and therefore, it is likely that this species is occurring in lower altitudinal regions of Bhutan. However, additional field surveys are required to establish its presence in the central and western regions of Bhutan.

The discovery of *Idionyx stevensi* in Bhutan marks the first records not only of the species but the genus itself. These are small sized dragonflies with emerald green eyes, a metallic green thorax with bright yellow stripes and an upward pointed carina on the tenth abdominal segment (Fig. 7A). The two adult males and a female were collected hanging from branches of small trees growing on the slopes above a roadside, while the weather conditions on the afternoon of that day suddenly turned dark and cloudy just before a light shower. The locality is also the only place from which this species has been caught in Bhutan. It is also interesting to note that it only adds to the fragmented distributional range of *Idionyx stevensi* in the region. Other previous records come from West Bengal in India (Fraser, 1936) and Nepal (Vick, 1989). Other record includes description of a larva from Shivapuri Hills in Kathmandu, Nepal, which emerged as a female adult (Butler, 2007). The current locality extends the distributional range of this species to the Eastern Himalaya.

Figure 7. *Idionyx stevensi,* Gyelposhing, Mongar District, Bhutan (9-vi-2017). Photo credits: Jan van Tol. (A) Male. (B) Female.

The sighting of *Sympetrum haematoneura* marks the fourth species in the genus recorded in Bhutan (Fig. 5). The other species previously reported are *S. hypomelas*, *S. fonscolombi* and *S. commixtum* all of which are widespread in Bhutan. *S. haematoneura* at location 25 marks its first record in Bhutan. Location 25 is a highland pond at an altitude of 1990 m a.s.l. The blood-red body, black humeral stripe and a broad black stripe along the lateral sutures, and slightly larger size distinguished the species from *S. fonscolombi* which was also present. *S. haematoneura* takes longer flights (like flights taken by *Tramea* species) and prefers to rest on grasses growing further from the edges of the pond. Unlike the other species of *Sympetrum*, *S. haematoneura* in Bhutan are sighted at standing waters like ponds and lakes (Fig. 6B). *S. haematoneura* has also been sighted at a pond in Bumthang district below Kurje monastery (21-vii-2018) and is likely to be present at ponds located at high elevations in other regions of Bhutan as well.

Tramea species are often difficult to catch owing to their robust flight. They prefer open standing waters. A tandem of *Tramea limbata* was caught at location 25. This is the first record for Bhutan. *T. limbata* is widespread in Sub-saharan Africa and in southern Asia, particularly in India where it is distributed throughout the country. As Bhutan is located next to India, it is most likely that *T. limbata* is a resident species and previously unrecorded owing to inadequate Odonata studies in Bhutan.

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Phylogenetic implications of the pterothoracic sternites of Odonata nymphs

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Introduction

The odonate thorax comprises a comparatively small prothorax and a bulky pterothorax. The skewed, fused arrangement of the odonate pterothorax is unique among insects. Not surprisingly, the pterothorax of odonate nymphs (or larvae, depending on viewpoint) is fundamentally similar to that of adults, in both obliquity of the conjoined meso- and metathorax and in the prolongation of the episterna in a dorsal direction to the extent that the left and right mesepisternal plates join at the middorsum of the thorax (Snodgrass 1954).

However, comparative external morphological study of the pterothorax of Odonata nymphs throughout the order has not been undertaken. It seems there is a perception that the nymphal thorax offers little taxonomic or phylogenetic information, and perhaps this view has been a dissuading factor in such studies. However, the adult pterothorax is greatly utilized in taxonomy, implying that nymphal thoracic morphology should also be examined.

In an initial examination of nymphs of several families, I noticed a difference in the size and shape of the ventral thoracic sclerites and in the development of the sutures that form these sclerites. Intrigued, I then focused on the area where the mesothorax and the metathorax join. Throughout the order, I found that, depending on the family, a distinct suture between the two thoracic segments was either present (segments separated) or absent (segments fused). And if a suture was present, the degree of movement between the two pterothoracic segments varied from flexible to inflexible. I therefore conducted a survey of as many families as possible to see which retained separation of the meso- and metathorax ventrally and which ones had the two segments solidly joined.

Materials and Methods

I gathered data on specimens representative of 31 families; each family was scored for presence/absence (+ or –) of a suture between the opposable meso- and metathoracic sternites, and for flexibility (F = flexible, I = inflexible) between the sternites. Examination of the thoracic venter was made under 12–25X magnification using a Wild stereomicroscope. Images were recorded using a Nikon D70s digital camera attached to the stereomicroscope. Terminology for the ventral sclerites is based on Asahina (1954). Although I personally examined specimens of the majority of the families, the only evidence I obtained for Chorismagrionidae was based on photographs of two early instars.

Results

The majority of families of Zygoptera had a well-defined suture between the furcasternum of the mesothorax and basisternum of the metathorax (Fig. 1A; Table 1). However, three families of the superfamily "Lestoidea" (Lestidae, Perilestidae and Chorismagrionidae) appear to have no suture (Fig. 1B). Photographs of *Chorismagrion* appeared to show a weak transverse demarcation, however I scored the genus as negative for a suture; more specimens should be examined. Specimens of Hemiphlebiidae and Synlestidae, two related families, were not available for examination. These latter five families make up the currently defined Lestoidea (not to be confused with the genus *Lestoidea* Tillyard which is in the family Lestoideidae and not a member of the "lestoids").

Conversely, in Epiprocta, the only family with a transverse suture at the junction of the mesothorax and the metathorax was Epiophlebiidae (Fig. 2A). In no Anisoptera family was a suture separating these two segments detectable (Fig. 2B; Table 1).

Nearly all Zygoptera families not only had a transverse suture but membranous cuticle was present along the suture. In the representative species studied in these families, there was flexibility between the metathorax and the mesothorax. Exceptions in the Zygoptera were Lestidae and Perilestidae, with a lack of flexibility between the metathorax with the mesothorax. I did not detect membranous cuticle along the transverse suture of *Epiophlebia*, and there was no flexibility between the meso- and metathorax of the two exuviae I examined; in other words, the two segments do not articulate with each other, but rather act as a single segment. Regarding fusion of the pterothoracic segments, *Epiophlebia*, except for possessing a transverse suture, is similar to the Anisoptera.

Discussion

Snodgrass (1954) based his study of the odonate nymphal thorax solely on an aeshnid, *Anax junius* (Drury). In this species, as in apparently all Epiprocta except *Epiophlebia* Calvert, the ventral suture between the mesothorax and the metathorax of the nymphs has been lost. Snodgrass may have assumed that all Odonata were similar to *A. junius* in morphology of the thoracic venter and consequently he did not discover the ventral meso/metathoracic

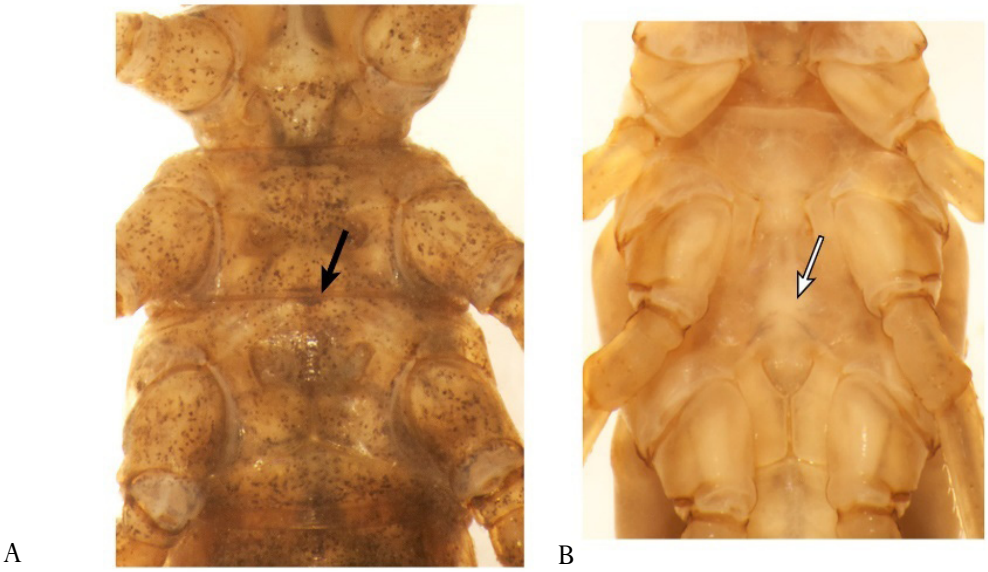

Figure 1. Zygoptera thoracic venter, final instar. Black arrow indicates transverse suture, white arrow indicates lack of a suture. (A) *Calopteryx dimidiata* Burmeister. (B) *Lestes eurinus* Say.

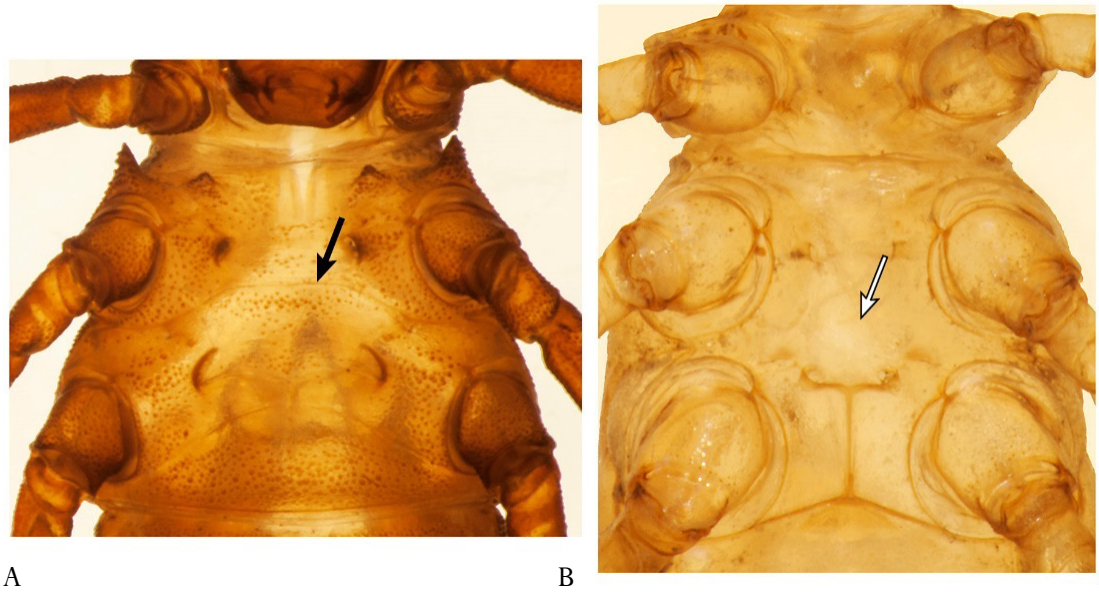

Figure 2. Anisoptera thoracic venter, final instar. Black arrow indicates transverse suture, white arrow indicates lack of a suture. (A) *Epiophlebia superstes* (Selys). (B) *Anax junius* (Drury).

suture in the vast majority of Zygoptera.

The separation of the odonate mesothoracic furcasternum and the metathoracic basisternum by way of a membranous fold and the evolutionary significance of this trait appear to have been overlooked. According to some phylogenetic studies based on adults (Bybee et al. 2008, Dijkstra et al. 2014), Lestoidea families are sister to the rest of the Zygoptera. In other studies (Saux et al. 2003, Hasegawa and Kasuya 2006), Lestoidea (only *Lestes* Leach in Brewester was included in these studies) are sister to Anisoptera. However, *Epiophlebia* was not included in either Saux et al. (2003) or Hasegawa and Kasuya (2006) and both studies were based on limited molecular data. Also of note, in Ephemeroptera (mayflies), the meso- and metathorax are clearly separated. Based on the opposing phylogenetic hypotheses and the assumption that Ephemeroptera is the sister to Odonata, two scenarios are possible for the evolution of the ventral transverse suture in odonate nymphs: 1) a single loss of the suture among Lestoidea and Anisoptera with *Epiophlebia* retaining the ancestral condition and maintaining a suture; 2) loss of the ventral suture has occurred at least twice in the history of the Odonata, once in the Lestoidea and another time in the Anisoptera. Based on current phylogenetic results, Lestoidea are strongly supported as sister

Table 1. Families of Odonata for which exuviae and/or nymphs were examined for presence (+) or absence (–) of a ventral transverse suture between the mesothorax and the metathorax; mes = mesothoracic venter, met = metathoracic venter; *includes Coenagrioninae, Protoneurinae, Pseudostigmatinae.

Family	Ventral suture (+ or –)	mes & met flexible (F) or inflexible (I)
ZYGOPTERA ("non-Lestoids")		
Amphipterygidae	+	F
Calopterygidae	+	F
Chlorocyphidae	+	F
Coenagrionidae*	+	F
Devadattidae	+	F
Dicteriadidae	+	F
Euphaeidae	+	F
Heteragrionidae	+	F
Isostictidae	+	F
Incertae Sedis Gp. 1 – *Heteropodagrion*	+	F
Incertae Sedis Gp. 3 – *Rhipidolestes*	+	F
Megapodagrionidae	+	F
Philogeniidae	+	F
Philosinidae	+	F
Platycnemididae	+	F
Platystictidae	+	F
Polythoridae	+	F
Rimanellidae	+	F
ZYGOPTERA ("Lestoidea")		
Hemiphlebiidae	no data	no data
Chorismagrionidae	–?	I?
Lestidae	–	I
Perilestidae	–	I
Synlestidae	no data	no data
EPIPROCTA		
Epiophlebiidae	+	I
Aeshnidae	–	I
Austropetaliidae	–	I
Petaluridae	–	I
Gomphidae	–	I
Cordulegastridae	–	I
Synthemistidae	–	I
Macromiidae	–	I
Corduliidae	–	I
Libellulidae	–	I

to the rest of Zygoptera and together they form a strongly supported monophyletic group (Seth Bybee, pers. comm.). Most likely, expression of a fused nymphal pterothorax in both Anisoptera and Lestoidea is convergent, and the loss of the suture in the order as a whole should be considered an example of homoplasy. Therefore, it is plausible that this character can be ordered in Odonata, a transverse suture present being the plesiomorphic condition, and loss of the suture an apomorphy. However, the loss of the ventral transverse suture in Lestoidea is very interesting in light of the tree proposed by Hasegawa and Kasuya (2006). Additional study of the thoracic venter will inform the higher classification and phylogeny of the Odonata. Of particular interest would be examination of crown fossil nymphs (although rare) to provide further insight into the ancestral condition of the suture.

One further note: As in most insects, the prothorax of Odonata nymphs is separated from the pterothorax by membranous conjunctivae, both dorsally and ventrally. However, I should say it is "usually separated" because a few genera of Gomphidae (e.g., *Progomphus* Selys, 1854, *Phyllocycla* Calvert, 1948) have the nymphal prothoracic furcasternum immovably attached to the anterior portion of the mesothoracic basisternum; in such cases, a transverse suture is present but it appears that the typical connective membranous cuticle has been drastically reduced. This ventral prothoracic-mesothoracic fusion is possibly a highly derived and specialized trait within the order, adaptive for a burrowing type of lifestyle.

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Adventures in Bakossiland – A short history of the Cameroon Dragonfly Project

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Shall we go north or shall we go south?

"Graham, don't argue, just get in the cab". We were at Douala airport in the middle of the night (the plane was 30 hours late) in July 1996 and surrounded by people whose sole intention was to rid us of our money. So how did we find ourselves in this somewhat unenviable situation. Even in the arrivals lounge the phrase "Shall we go north or shall we go south" was still ringing in my ears. A decision was made: Don and Graham in the first cab, Pete and me in the next. We drove off into the pitch dark – where were we going? Was this even a cab? With visions of white slavery still uppermost, we thankfully arrived out of the gloom into the Hotel Ibis. Sloughing off the ladies of the night, we checked in to two rooms. I remember saying to Pete at the time "you were quiet in the back." "I should think I was" he replied "I was doing all I could to hold the b****y doors shut". We had arrived in Cameroon.

Cameroon – Why, Where and How?

Kingdon (1990) describes Cameroon and, in particular the border lands with Nigeria, as the Bight of Biafra often called somewhat disparagingly, "the armpit" of Africa (Fig. 1). This is the wettest part of the continent (Debundscha on the southern coast of Cameroon has almost 10 m of rain per year). A land of many rivers including the Cross, Mungo and Sanaga, it is 'never less than warm' and around Mount Cameroon and the Cameroon highlands, persistent rain clouds greatly reduce the hours of sunshine and where any exposed soils are quickly leached of humus and minerals. Despite these factors the Bight of Biafra supports one of the greatest concentrations of plant and animal life on the entire continent. And there is yet another factor of great interest to the biologist. The Cameroon highlands which spread along the crease of the armpit, are mountainous areas covered in rainforest that, unlike most lowland habitats, have remained unchanged by geology, climate and human intervention over eons, possibly even as far back as 200 million years when Africa formed part of the huge Gondwanaland supercontinent. In summary the Highlands are centres of endemism, of huge biodiversity and where plants and animals flourish that are found nowhere else in the world. What possibilities for an odonatologist?

Be in no doubt, the Cameroon Dragonfly Project or CDP as it was widely known, was the brainchild and creation of Graham Vick. Graham's interest in Africa goes back to the 1980s in discussions with Robert Gambles, Mike Parr and Philip Corbet; but then there was an out of the blue invitation to the staff at Shiplake College where Graham was a teacher. This came from a physiotherapist called Selina Furth, who worked at the Catholic Mission in South West Province. Quite fortuitously at this time, Graham had contact with Chris Gibbins of the University of Northumbria, a birdwatcher

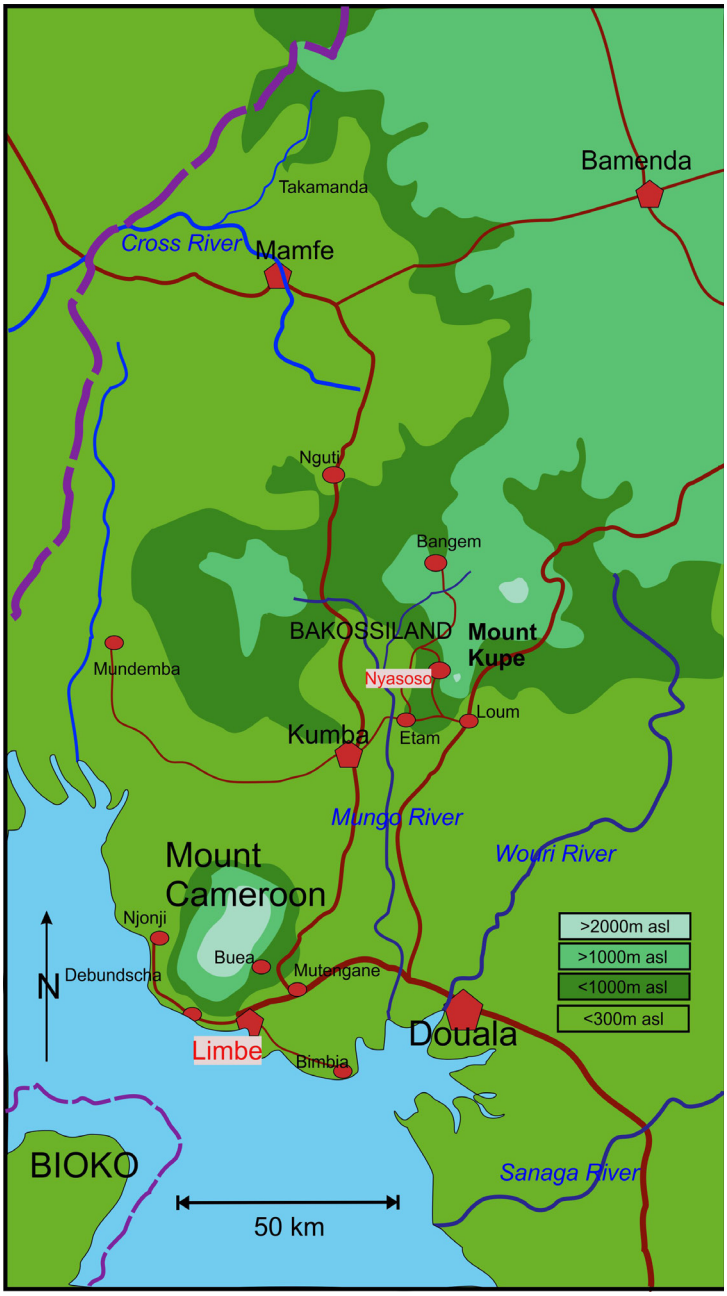

Figure 1 – Map of South West Cameroon

who had visited Mount Kupe at the southern end of the Cameroon Highlands. He was able to provide contacts and a sketch map of how to access the forest. With both these events occurring together the first trip was planned by Graham and Mary Vick for the Easter holidays 1995. For Graham, Cameroon at last – a long awaited goal

The first challenge was taxonomic; there was no 'book' for Cameroon and something had to be done. Graham prepared a checklist and key using *inter alia* Elliot Pinhey's taxonomic framework, Robert Gambles' unpublished Nigerian handbook, and innumerable trips to the Natural History Museum in London. But would it be sufficient to tackle the incredibly biodiverse fauna on the ground?

This trip was very successful, contacts were made and the potential of the dragonflies of the area realised. A special delight was that the four phylogenetically interesting damselflies were found on the streams of Kupe, and many other local specialities. It had been a gamble that Kupe would hold the endemics, it paid off and future trips would be required. Mary decided that one trip was enough and after some persuasion and a *Carpe Diem* moment, I agreed to join. In 1996 the CDP was formed with Otto Mesumbe a village farmer in Nyasoso as our Cameroon coordinator. The late Philip Corbet was our very enthusiastic president and plans were made for the first visit by the fledgling organisation. We decided on July, my friend Pete Mitchell offered to come along and together with book dealer and entomologist Don Tagg, we made up the team that found itself at Douala airport in the unenviable situation outlined above.

But where to go? Climate data indicated that SW Province (Kupe) receives its maximum rainfall in July and Kribi , in the south, was suggested as it would be dry. Eventually, in the lobby of the Hotel Ibis in Douala, we decided on Limbe and the rest is history. Perhaps we were lucky as July is a mini dry season at Kupe.

The CDP made a total of five visits to Cameroon: Easter 1995, June/July 1996, March 1997, November 1998 and finally in March 2003. The visiting participants were Graham (1995,1996,1997, 2003) myself & Pete Mitchell (1996,1997,1998) Don Tagg (1996), Jonty and Wendy Denton (1997), David Pryce (1998 and 2003), Gavin Stewart (1998), Graham Dennis and Joan Childs (2003). Pete Mitchell extracted all the trip records and put them into an excel spreadsheet database which has been widely used. Jonty did work on water beetles of which more later. David Pryce took photos and wrote a brief account of the 1998 trip (Pryce 1999). He also produced maps of species for the South West Region, which are as yet unpublished. Gavin Stewart was our resident photographer in 1998 and generously provided copies of his 35 mm slides. Our research was carried out from two centres (Fig. 1): Limbe studying lowland forest and Nyasoso for Mount Kupe and its environs. The prime purpose of the CDP was to increase the knowledge of tropical African dragonflies by focusing on the fauna of these two areas, tackling any taxonomic problems that occurred, and discovering the distribution of the species, and also identifying any 'hot-spots'. As a result the list for South west Cameroon was increased to 179 species (Vick 1999). In total seven new species (one in synonymy) were described as well as many first descriptions of larvae (and with many still awaiting description). The CDP's contribution to the study of dragonflies in Central Africa is recognised in the IUCN Red List (Dijkstra et al. 2011). A list of papers produced by and associated with the CDP is included in the references. In addition, it provided opportunities for employment and education to local people. This article documents the work carried out by the CDP, its travels, some of the species (not just dragonflies) encountered and stories of the fascinating people, cultures and situations encountered together with local attitudes to the rain forest which dominates this landscape. We hope you enjoy it. A word of caution, it is as well to remember that back in the 1990s digital photography was in its infancy and such cameras unreliable in the damp tropics. All photos were, therefore, taken using 35 mm slides and have been scanned using a hi-res scanner; the images are not of today's quality.

Landscape and vegetation

We considered producing a vegetation map for the region but quickly discounted the idea as being far too generalised. In summary, apart from the upland area around Bamenda (Fig. 1), which is deciduous forest going into savannah, the remainder is a combination of chop (forest cleared for cultivation), bamboo, primary and secondary forest together with, mainly in the south west, oil palm plantations. The uplands and particularly the land above 1,000 m are mainly primary montane forest (Fig. 2A). The lowlands to the north around Takamanda are mainly primary forest and home to the Cross River Gorilla (*Gorilla gorilla diehli*), which was being intensively studied at the time of our visits (Comiskey et al 2003).

Travelling around Cameroon

I am looking at a map of Cameroon dated 2000. It looks impressive with fine thick yellow and thinner red roads networking the South West Province. Most of the larger towns have airport symbols. Impressed – don't be. If there is an airport outside a town, the chances are road links are hopeless. The saving grace for the road transport system is the beer truck (Fig. 2B). Most of even the smallest villages have beer, and it has to be delivered so roads (more like tracks), no matter how poor, are kept in some degree of maintenance. Edepang-Koge (1986) describes the dry season as December and January when "the roads become dusty". However, he goes on to state that "there is no really dry month". We visited during the months of March, April, June, July and November and experienced

quagmire roads on all trips. The problem back then was that only the key routes were metalled and the maps give a very false impression. Perhaps the most absurd example was the trip we attempted to make in 1998 from Nyasoso to Takamanda in the north of Bakossi; an area of almost virgin lowland forest and home to the highly endangered Cross River Gorilla. We set off from Nyasoso and arrived at Kumba without incident. Just north of the town the road started to deteriorate, we crawled along following the beer truck around and through the most promising potholes and through thick vehicle high ruts at 15 km/h. Then, just past the village of Mbakwa- Supe there it was: we were driving along a brand spanking new viaduct (Fig. 2C) built by the Koreans, whose presence is still evidenced today in some of the people of the nearby villages. We sped along at 100 km/h around its sinuous flowing curves through the middle of virgin rain forest, waterfalls everywhere but inaccessible many metres below the road. It was the strangest feeling riding in the van without banging my head on the roof. But then as quickly as it had started, we were back literally down to earth, potholes and ruts at 15 km/h. But this wasn't the end of the surprises for as we approached the town of Nguti so the roads were metalled and it was back to 100 km/h. Here we travelled so fast that the children no longer ran towards the van shouting "Whiteman" but were held back by their parents; the new road posed a new danger. The town of Nguti was another anomaly, great roads, ignored by the locals except as a resource for drying their produce; but no electricity. We did eventually arrive at Mamfe some seven hours after our start, however a huge storm that night meant that the old logging road up to Takamanda was too dangerous and we had to turn back. Figure 2D shows another main road, a far cry from the beautiful viaduct, the state of which curtailed our trip to Bangem in 1997. At the time, I remember Mbwange, our driver in 1996 and 1997, proudly showing me his machete and asking what type I kept in my car back in England?

Languages

There are more than 200 languages spoken in Cameroon. Many locals spoke English, French, their local language and Pidgin although the latter is now frowned upon and the learning of it

Figure 2. (A) Virgin montane forest of Mount Kupe rising above Nyasoso School and some of the 1998 team ready for work. (B) The beer truck and secret of the road system. (C) The Mbakwe-Supe viaduct surrounded by virgin forest. (D) The road to Bangem (Fig 1) in March 1997 at the end of the dry season! Photo credits (A & C): Gavin Stewart. Photo credits (B-D): David Chelmick.

discouraged. There was even a sign on at the secondary school in Nyasoso which read "War against Pidgin – I have chosen English and French. Pidgin is a disgrace". The problem is that Pidgin is a very practical language for everyday life. I can give you a simple example. In 1997 we were staying with Mama Henry in Nyasoso. We had decided to do some experiments in the forest; treehole traps to attract particular dragonflies. We needed plastic bottles and I tried to communicate in my best and clearest English what was needed. I approached in all sorts of ways but was getting nowhere until Otto appeared, grabbed the bottle and said "more tings dis kind". I was immediately inundated with bottles from every household. Problem solved. I do remember one evening down in Limbe when we had had far too much Afofo (distilled palm wine) and Graham, with his academic hat, trying to encourage Otto to tell us how the future perfect might be attempted. Tragically due to the drink I have no recollection of the outcome although Graham tells me that you can indeed say anything in this very expressive language. Still my favourite word "basketblongtiti" – you work it out.

Don't forget the chief

Soon after our arrival up in Nyasoso, we visited the village of Ngusi, spotted some good habitat and leaped out of the vehicle and into the stream. Otto looked nervous and wouldn't join us. We soon found out why. A group of villagers came up and almost literally marched us off to the village, to the chief's palace to be exact. When I say palace, it was a large room quite bare apart from some old Sylvester Stallone and Arnie Schwarzenegger posters and some plastic chairs. Otto disappeared with a couple of villagers returning moments later with beer and a bottle of scotch. The chief and his henchmen soon appeared and he started to berate Otto (in Bakossi) for allowing us visitors to enter his lands without permission. Otto was suitably contrite and was handed some nuts, which he had to throw onto the ground. The chief looked at his elders and they all shook their heads, this was what happens when you don't do things properly. The chief then took the nuts and threw them, the pattern was now correct and we could be allowed to visit the forest. But first the ceremony; the whisky was opened and a few drops were spilled to the ground to appease the ancestors. The chief's words followed with much shushing from the elders then beer was circulated, the nuts chopped up and passed round. Cola nuts, apparently slightly hallucinogenic; I thought they were disgusting. Anyway we were eventually allowed to leave after further payment of 10,000 CFA (20 Euros) and progressed to the field. The procedure had to be followed whenever we visited a new area (Fig. 3). Where we went wrong was not following the great Gerald Durrell's advice. When he visited Cameroon he spent most of his time whooping it up with the chief sending the villagers out to do his collecting.

Lowland - Limbe and environs

Our first studies were carried out in and around Limbe which is a large coastal town and home to the Limbe Botanical Gardens and its accommodation block which was our base. The Atlantic Beach Hotel whose strap line was "We offer more than we promise". I never could work that out. We used to breakfast here often watching the African Giant Kingfisher (*Megaceryle maxima*) using the balcony as a fishing point. The staff used to chase it off until they got the message that we loved it. Our nearest and best value restaurant for dinner was in the edge of the town; originally called the Tekou International Restaurant, international because it served up pasta as well as rice. Its staples were beef, chicken and fish but we suspect that bush meat of various varieties were used. In 1998 the Tekou changed its name to the Britannia. It had been bought by a Englishman who died of yellow fever soon after it re-opened

Lowland areas in the tropics and particularly this part of Africa were known as the white man's grave and for good reason, spending long periods here was not to be recommended as malaria was a constant possibility as well as other diseases. Rumour has it that Chris Wild, one of our key contacts, had spent so many years living and working in lowland forest that he had blood diseases named after him! We took mosquito nets but never used them. We took anti-malarial drugs but were informed that the best way to avoid the disease was to refrain from connubial relations with local people. Please – we are here for the dragonflies! One local pest that did need attention was the tumba fly (*Cordylobia anthropophaga*); its specific name shows its attachment to man. The females lay their eggs in soil or damp cloth. The larvae then emerge and burrow into the skin. The sweaty waste bands

Figure 3. The Chief of Ngombo Aku and his retinue in front of his palace. Photo credit: David Chelmick.

of trousers are a favoured habitat and these need to be sprayed heavily with Deet to discourage the insect. I remember on our 1998 trip Gavin complaining about the Deet clouds. He failed to take the precaution and was quickly infected. Fortunately by then "Dr. Mitchell" was a dab hand at solving the problem. The larvae breathe through a tiny opening in the skin. A little Vaseline starves the beast of oxygen and it dies. "Dr Mitchell" would then take finger and thumb and deftly extricate the dead insect before any damage was done.

Figure 4. *Phyllogomphus selysi* collected at Bimbia on the Elephant River and described in Vick (1999). Photo credit: David Chelmick.

With respect to the dragonflies, the principle problem with lowland habitats is usually related to water temperature. The streams, pools etc are in excess of 25 °C which permits rapid larval growth of common species that tend to crowd out the more interesting fauna. The other problem especially in cultivated areas is bilharzia, which is a water snail-borne debilitating disease requiring protective clothing when studying in such areas. Hot and cumbersome, the clothing made for difficult field work so we concentrated on forested lowland streams. In general our collections of common lowland species was very poor, however, we had some success and I particularly recall Graham catching a large *Phyllogomphus* (Fig. 4). Clearly the genus is reasonably common here as David Pryce found exuviae along the Limbe river next to the Botanical Gardens in 1998.

Uplands and Montane - Mount Kupe and Nyasoso

The real object of our research was to be Mount Kupe and its environs in the heart of Bakossiland, so named after the Bakossi tribe, which inhabits this region with its own customs, language and even religion, although Christianity was strong in many villages. Our base was the town of Nyasoso, which provided easy walking onto the mountain trails. Unlike the cloying wet furnace that was Limbe, Nyasoso had an all-year-round temperature in the upper 20s °C and a tolerable humidity. Sleeping here would not be a problem, unless of course you liked a lie-in. First year we stayed with Jacob (full name Ngome Jacob Kolle). We stayed in his house with his large family. It was most hospitable with fine food and excellent facilities. He even had his son clean our shoes, removing the laces and washing them first. The only downside of Jacob's was that the back of the house where we slept was where the village tap was situated. Many houses had a piped system from the water catchment high in the forest, but others relied on this tap. I can still remember the sound of water falling into steel buckets at 5:45 and then continuously. Even if you could sleep through this then Jacob's born-again Christian group parading around the house with sticks and pans praising the Lord, got you out. Getting up was never a problem for Pete, always an early riser; he would be out on the terrace at first light and occasionally be lucky enough to see the African Grey Parrots (*Psittacus erithacus*) flying over to feed. One morning at breakfast there was a great commotion as the next door farmer tried to scare off a Giant Sparrowhawk *(Accipiter m. melanoleucus)* that had come to his hens in search of his own breakfast.

In 1995 when Graham and Mary first visited Nyasoso, there was no electricity. In 1996 Jacob was watching David Attenborough even though he didn't have a fridge. I remember him asking one day what cold was and whether anybody in England went outside in the winter. However, the evolution of electricity in Nyasoso took a real turn for the worse in 1998 when Jacob obtained his chiming clock, and no ordinary clock - for on the hour every hour a new tune was provided. At first you block it out but at 2:00 in the morning when you are drifting off, two choruses of Colonel Bogey are not conducive to a good sleep. Eventually we convinced him to turn off the sound at night. He was quite affronted that we did not appreciate his miracle device. Discussions with Jacob often took place after dinner between episodes of Zoo Quest (David Attenborough). Jacob was teetotal, we were on the Afofo and so at a disadvantage. The discussion usually centred around the forest and went somewhat on the lines of. "You in Europe are rich, you have cut down your forests. Surely we can only be rich if we cut down our forests." We could not fault the logic until we got onto the subject of water when Jacob would grudgingly admit that, without the forest, the soils would simply be washed away by the intense rains and the water catchment, and yes including the dreaded tap, which was the lifeblood of the village would not exist.

Our path into the forest took us past the extensive buildings of the secondary school (Fig. 2A), which was one of the most important in the area. There were a number of trails, Max's, Shrike and the Nature trail which gave access in varying degrees of difficulty to streams, seepages, a waterfall and the water catchment which provided water for the village. However, before we could access the forest we had to make

contact with the office of the Mount Kupe Forest Project, a conservation venture sponsored by Birdlife International. It was from here that permits were granted for access and collecting. No chief visits here although in 1998 we did visit the paramount chief of the area to thank him for his permission to visit the forest.

Our first large wildlife contact came early in our first trip to Nyasoso when a young lad appeared one evening with a baby Pangolin (Family Manidae)(Fig. 5A). An endearing creature that could break hearts, how could we not be tempted to make a purchase and free the animal. The reality was, of course, quite different. The mother had already been caught and sold or eaten, the baby would never survive on its own and our purchase would simply encourage more hunting. We declined.

When Graham first visited Kupe, virtually nothing of the dragonfly fauna was known. It was however a well known bird site, its most celebrated inhabitants being the Mount Kupe Bush Shrike (*Chlorophoneus kupeensis*) and the Grey Necked Rock-Fowl (*Picathartes* sp.). The latter breeds in caves in the forest and was only discovered on Kupe in the 1990s. The Bush Shrike is a very hard-to-see species that is endemic to Cameroon and classified as endangered. Jonty, our bird man in 1997 succeeded in seeing 14 rock-fowl sitting on a tree near a large cave. Unfortunately, the Bush Shrike eluded him. I have no bird pictures but the Mount Kupe Forest Office was gaily decorated and had drawings of both species (Fig. 5B). Jonty's interest was also in water beetles on which group he is an authority. His collections were very productive. Hernando & Ribera (2000) described *Cyclolimnichus dentoni* from Jonty's Cameroon material. In addition, he collected only the second specimens ever of a species of water penny beetle (family Psephenidae), which is a small family found in most continents and its species are indicators of excellent water quality. In addition, DGC passed all his collections of beetles to Jonty. These included *Ora* and *Copelatus* species, which are new but have yet to be described. Hymenoptera and Trichoptera (Caddisflies) were collected in Malaise trips in 1995 and 2003. Needless to say, there were always new species to science at Kupe!

Pete Mitchell had a unique approach to field work; Instead of rushing around like the proverbial headless chicken busying in streams, he would stay put in one part of the forest and just watch. This approach had many rewards for birds but the most notable was on Friday 13th 1998 when we were near Ngombo aku, still at altitude and some 15 km north of Nyasoso. We met with the chief and moved through the chop into bamboo forest and then into the rain forest. Pete was behind us with our driver Fasso. They were rewarded with splendid views of bushbabies, first in the bamboo and then in the deep forest, perfectly in view in the binoculars. According to the web this was the Northern Needle-clawed Bushbaby (*Euoticus pallidus*) endemic to west central Africa particularly in high altitude and high rainfall areas such as Mount Kupe and Mount Cameroon. Pete was in reflective mood when explaining his find. "Trouble with you Chelmick, you spend too long with your head up you're a**e!"

Chris Wild was one of our key contacts in Nyasoso and a professional herpetologist. He explained that Kupe and the Cameroon Highlands are a very rich area for Ranidae (true frogs), which can be found in a huge number of species but none more impressive than the Goliath Frog (*Conraua goliath*), which has the distinction of being the largest in the world (Fig. 5C).

Jacqui Sunderland Groves and husband Terry Sunderland (experts on primates and palms respectively) collected specimens in the forests of

Figure 5. (A) Baby Pangolin offered to us for sale for its freedom, an offer we declined. (A) The Mount Kupe Forest Office in Nyasoso. (C) A young Goliath frog in the hands of Chris Wild at Nyasoso. Photo credits: David Chelmick.

Takamanda (where the Cross River Gorilla is found). This produced some very useful material which was distinct from that of the Bakossilands.

Dragonflies of Mount Kupe

A total of 25 species were recorded from Mount Kupe by the CDP, with some still to be described, a relatively small number but these are montane rain forest specialists that survive because of the constancy of the conditions and the coolness of the water rarely exceeding 21 °C. Perhaps the most interesting species is *Pentaphlebia stahli* - one of just three species in their own family the Pentaphlebiidae. The adult is a large quite unmistakeable red damselfly (Fig. 6A) that can be found around the upland streams and seepages; but it is the larvae that are of particular interest. They are adapted to clinging to rocks and logs in the fast flowing streams and indeed share this habitat with the waterpenny beetle larvae found by Jonty. The larvae have strange adapted paraprocts and branched epiproct, which are structural and cannot assist with oxygen transfer like normal lamellae. For this reason gills are present next to the anus, at least in the early instars (Fig. 6B). The larvae look very similar to an unrelated species in South America called *Rimanella arcana* which breeds in similar montane habitats, albeit the relationship is now believed to be less close than previously thought.

Other damselflies that flourish here are of the genus *Stenocnemis* (Fig. 6C) and *Chlorocnemis* with their tiny blobs of colour brightening the otherwise dull green habitat. *Neurolestes trinervis,* is also remarkably similar in markings

Figure 6. (A) *Pentaphlebia stahli* adult male from Mount Kupe (B) *Pentaphlebia stahli* early instar larvae showing the gill tufts which replace the lamellae in oxygen transfer. (C) *Stenocnemis pachystigma* a damselfly found breeding in the waterfall at Mount Kupe. (D) *Nubiolestes diotima* on Mount Kupe. The only species of Synlestidae in Africa. Photo credits: David Chelmick.

and colour pattern to *Stenocnemis*, although not closely related. We found larvae that have been presumed to be *Stenocnemis* living in the water film associated with a vertical waterfall. Last, but by no means least, and considered by Dijkstra et al (2011) as the defining damselfly of Kupe, *Nubiolestes diotima* (Fig, 6D), the only central African species of the Synlestidae. The CDP made the first description of the larva of this species (Vick 1998).

Vick (1999) provides a detailed checklist of the CDP findings, other papers detail the new species (see references and Fig. 7A). I have no intention of repeating such excellent information but to look at some of the notable species of the mountain. The genus *Phyllomacromia* is endemic to Africa and seven species have been found in our area of which two species, *P. aeneothorax* and *P. caneri,* are found in the streams of Mount Kupe. We have only found the former on Mount Kupe itself whilst *P. caneri* is more widespread in the uplands. I first encountered *P. aeneothorax* as larvae in the sandy streams in the forest. Unlike the closely related *Macromia splendens* from Europe, which lives in collections of detritus and leaves in river pools, *Phyllomacromia* prefers simple sandy streams where it buries shallowly in the substrate (Fig. 7B). The way to find it being simply to push the riddle into the sand and the larvae will immediately move and swim off. The adults fly in deep forest behaving much as *Macromia* in Europe. *P. caneri* flies in more open habitat in upland streams but can also be found on Kupe. Eye colour appears to be a good way of separating the two. In *P. aeneothorax* the eyes are a sombre green blue whilst in *P. caneri* they are much lighter yellow green.

Another curiosity found in the seepages of Kupe and some surrounding areas is *Idomacromia proavita*. A beautiful species whose familial status is still uncertain. I remember collecting adults at Etam near the Mungo River in 1997 (Fig. 7C). Graham had decided this area required chest waders, which almost caused him to faint with the heat. I,as usual, was moving further downstream. We had visited the chief; but nobody had warned the village ladies who were bathing and were somewhat surprised to be confronted by a very embarrassed white man; I beat a hasty retreat.

We finished the day by riddling what looked like a tiny pool next to the stream, we were making little progress until Jonty appeared with his long handle aquatic net, which he pushed deep into the pool and came up trumps with treasured larvae.

Collecting and preserving the lads – specimens

In areas of the world where the fauna has been well worked, collecting of specimens is now thought to be distasteful and unnecessary. This is not the case where the fauna is virtually unknown; specimens have to be collected, they could be new or very little known. This was the situation that faced us in

Figure 7. (A) *Notogomphus moorei* male photographed by David Pryce. This is one of two species of *Notogomphus* described by the CDP (Vick, 2003). The other species *N. maryae* was named after Graham's wife who died in 2005 and was described from a specimen bred out by the CDP. (B) *Phyllomacromia aeneothorax* larvae on the sandy substrate of the Mount Kupe streams. (C) *Idomacromia proavita* female from Etam. Photo credits: David Chelmick.

Cameroon. Larval collection is easy – so long as you have alcohol there is no problem, if desperate you can even use Afofo. The problem comes with the adults. Once collected they need to be put into acetone which is a rapid drying agent that, to some extent, preserves the colours and is a fat solvent. So how to get acetone in Cameroon? Some outlets viewed the request with suspicion as it can be used in 'cutting' drugs. On our first trip we made numerous trips to pharmacies all the way from Douala to Limbe buying nail polish remover, despite strange looks we got sufficient supplies. On our 1997 trip we waited until we arrived at Limbe where we met Nicholas, a real charmer and our designated "Mr Fixit"; tall, good looking, heavy shades, colourful shirts and always carrying an umbrella. "You want acetone Mr Graham, leave it all to me". So we did and a rather excessive price was paid for poor quality acetone. Graham was less than impressed.

Normally once removed from the acetone, the specimens would simply be left to dry off. But this is the tropics, a permanently wet environment. Specimens simply left would soon deteriorate and go mouldy. Graham was forced to develop a new system from an idea given to him by Jerrell Daigle in Florida, which involved drying the post acetone specimens with a hairdryer. Either the specimens were placed in a box inside a plastic bag into which the hair dryer discharged or each was held for personal grooming (Fig. 8A). This way the finally dried specimens could be stored in sealed boxes ready for transportation. I should like to point out here that full permits were obtained for collection and transportation out of the country.

Larval Breeding Project

After our second trip in 1997 I produced a key to the larvae to facilitate identification in the field. Due to its preliminary nature this was never published; however it was referred to in Suhling et al (2014). One of the problems with larvae is their association with the adult insect. For certainty, the solution is to find both together. We tried making emergence traps and placing them in habitat. This has never been effective; larvae appear to have an innate ability to avoid this obvious danger. The next alternative is to breed the larvae out: take late-instar larvae, feed, then when final instar shows signs of emergence, cover with netting and wait for the result. By transporting the larvae in damp socks or underwear, the CDP has bred out a good number of specimens back here in UK. This relies upon transporting material, far better to carry out the breeding on site and one of the key initiatives of the CDP was to set up a larval breeding scheme in the village at Nyasoso run by Otto. It started out as a few buckets covered in netting but eventually progressed to a shed with much material (Figs 8B & 8C) that produced adult *Notogomphus, Phyllomacromia* and a rare *Tragogomphus* collected in 2003. The other great advantage of this type of project is that it can

Figure 8. (A) Graham studying and Pete drying specimens at Jacob's in 1996. Photo credit: David Chelmick. (B) The larval breeding centre in Nyasoso with newly emerged dragonfly in cage. (C) Otto next to the larval breeding centre. Photo credits (B-C): Graham Vick.

produce surprises, even species rarely seen as adults, perhaps tree top fliers or species out of the ordinary flight patterns. In addition, we have a considerable number of late instar exuviae that can be associated with adults one of which *Urothemis venata* has already been described (Chelmick et al. 2019). In addition, we have an additional source of material. Sarah Corbet (sister of Philip) visited Cameroon in the 1970s and published some of her dragonfly findings (Corbet 1977). Knowing of our work Sarah generously donated her collection (adults and exuviae) to the CDP. Work on the exuviae and larvae is underway with the eventual aim of publishing the key to larvae. The work of the CDP continues.

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So many people have been involved with the CDP that it is almost impossible to be exhaustive and I apologise in advance if I leave anyone out. Elvis Njume, and later Dora, both great riddlers for larvae. Henry and Ebong, tireless workers for the Mount Kupe Forest Project and very helpful in providing access to the streams and wetlands of the mountain. Chris Wild, a professional herpetologist and his partner Illanga. They provided invaluable information and contacts and a great deal of background information on the region. The staff at Limbe Botanical Gardens especially Okah who facilitated our transport for all the trips. To Mbwange and Fasso our drivers. To Ray Andress who provided the illustrations for Graham's papers (see references). To the international organisations including C.R.E.S at San Diego Zoo, Royal Botanic Gardens at Kew and Birdlife International who ran the Mount Kupe Forest Project. Finally, to the staff of the Natural History Museum in London for access to the collections on which the original keys were based.

Conclusion – Cameroon and its current crisis.
So what of our intrepid band, what has happened to them and indeed the country in the intervening quarter of a century? The CDP effectively came to an end after Otto and Chris Wild left Cameroon in 2005. Attempts were made to continue the larval breeding programme but these failed. Otto now lives and works in California with his wife Mercy and their three children. Elvis and Ebong are still in Nyasoso. Dora, who was chief riddler on our 1998 trip died three years ago. She had been working in Douala. Mama, our hostess in Nyasoso in 1997 died some years back but Jacob and his wife are living in Maryland, USA with their daughter. He is very frail now and has lost three of his eight children. Chris Wild who was such a vital part of our work disappeared for a few years; but Graham has made contact again; he is in West Malaysia working on snake-venom projects.

The Mount Kupe Forest Project was abandoned many years ago and South West Cameroon is no longer safe to visit. There is basically a language divide between anglophone separatists and francophone government troops which is leading the province to near civil war with village burnings and other atrocities close to Mutengene, where Selina, Graham's original contact, worked. It is no longer safe for foreigners to visit this beautiful country, the secondary school (Fig. 2A) in Nyasoso through which we walked to the forest is, like all schools in the area, closed and is gradually being reclaimed by the forest.

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Dragonflies in "the land of the Gods" Impressions of a dragonfly survey between Mussoorie and Yamuna, Uttarakhand, India

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Introduction

Uttarakhand is a state in northern India that was carved out of the Himalayan and adjoining districts of Uttar Pradesh as the 27th state of the Republic of India on 9 November, 2000. Originally named Uttaranchal, in January 2007 its name was officially changed to Uttarakhand, Hindi for North Section or Segment. The state shares international boundaries with China in the north and Nepal in the east, and state boundaries with Himachal Pradesh in the west and Uttar Pradesh in the south (Figure 1). Biogeographically it is situated in the West Himalaya (Chandra et al 2018).

The state Uttarakhand is often called "the Land of the Gods" because of its numerous Hindu pilgrimage sites. It is also well-known for its many snow peaks, glaciers and rivers. Its southern slopes are steep and well forested, while their northern counterparts are largely endowed with grassy vegetation. Geographically the state is situated between latitudes 28°43'-31°28'N and longitudes 77°34'-81°03'E. Uttarakhand has an extensive system of snow-fed, perennial and seasonal rivers, some of which are voluminous and fed by the glacial zone of the Himalaya, while others are smaller, originating from the forested zones of the lower Himalaya. The main rivers are the Yamuna, Ganga, Ramganga and Kali (Tak et al. 2010).

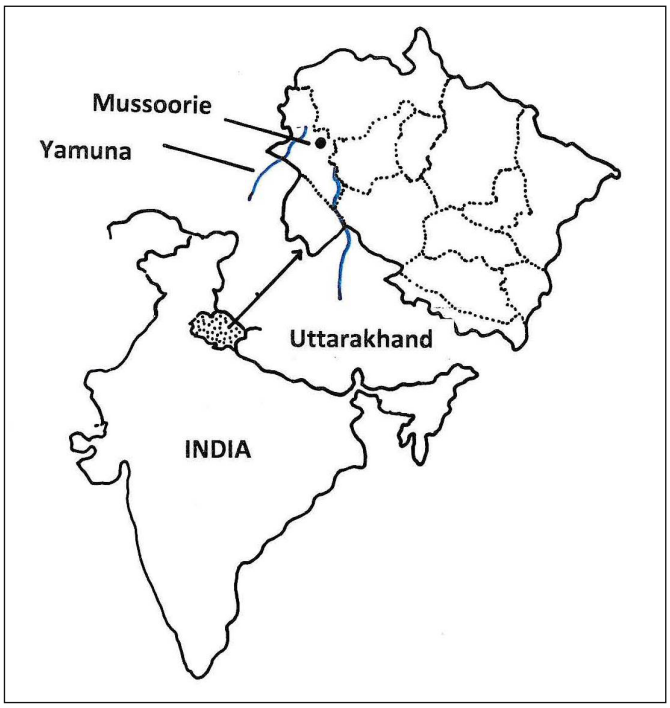

Figure 1. Geographical situation Uttarakhand and Mussoorie Range.

The average temperature varies during summer from 11 °C to 45 °C and in winter from 2 °C to 32 °C. At higher elevation it remains cold throughout the year.

Uttarakhand is a paradise for odonates. Over a number of decades it has been visited by many odonatologists, including F. C. Fraser, S. Singh, S. Asahina, D. N. Sahni, A. Kumar, M. Prasad, M. Lieftinck, T.R.Mitra and A Mitra who have documented the taxonomical and bio-ecological aspects of its dragonfly fauna. *The Fauna of Uttarakhand* provides a list of 47 species of damselflies (Zygoptera) and 75 species of dragonflies (Anisoptera) (Prasad & Mondal, 2010; Prasad & Sinha, 2010).

Compared with other parts of India, the odonate fauna of Uttarakhand has been reasonably well investigated. Nonetheless, there still remain many parts in the state for which data on the dragonfly fauna are entirely lacking. In certain formerly well-studied regions there is moreover little information on the situation today.

Between 12 August and 19 August 2019 the authors undertook some dragonfly fieldwork in the northwestern part of Uttarakhand, in the region between Mussoorie and Yamuna Bridge. We here report our results.

Mussoorie is a hill station and a municipality in the Dehradun District of Uttarakhand. It is about 35 km from the state capital of Dehradun, and 290 km north of the national capital of New Delhi. Mussoorie and its surroundings have an average elevation of about 2,005 m. It has a fairly subtropical highland climate for the mid-altitudes Himalaya. Summers are warm and very wet, with July and August averaging approximately 660 mm of rain per month owing to the orographic lift of the extremely moist monsoonal air. The pre-monsoon season in April and May is warm and dry, giving way to rainfall from mid-June, while the post-monsoon is also dry but substantially cooler.In winter, rainfall is more frequent than in pre- and post-monsoon, but the weather is cool and cloudy. The region usually has a few spells of snowfall in December, January and February, though the number of snowy days has fallen in recent years, the result of a combination of local and global factors such as deforestation, agricultural activities and global warming.

Study sites

For our dragonfly trip we set out from Kempty Falls, 15 km from Mussoorie, in the direction of Yamuna River, following the Mussoorie Chakrata Road and stopping at locations where dragonflies might be expected.

Location 1: several km from Kempty Falls (30°29'42" N-78°01'39"E, elevation 1,320 m (Figure 2A and 2B).
Mountain stream originating from a forested area, ending in a small waterfall pouring down from overhanging rocks, forming a small cave not visible from the roadside. Inside this small cave the waterfall collects in a pool that is shaded by the rocks and their dense vegetation: bamboo, palms, big ferns and giant nettles. The inside of the cave is covered with mosses, algae and small ferns (*Adiantum*). Sunlight cannot penetrate and the microclimate here is cool with a high humidity. This location turned out to be the favourite habitat of *Megalestes major* (Figure 2C). We observed one pair in tandem and three other males. These males were generally perched near the waterfall on the inside of the overhanging rocks, where they were almost invisible. Sometimes they briefly flew, chasing each other and defending their favourite perch.
Near the entrance of the cave we also found two males and one female of *Calicnemia doonensis* basking in the sun on nearby shrubs.

At one point the pool overflows, creating a small stream that stagnates amongst ruderal vegetation, with a muddy, shaded spot only receiving sunlight early in the morning. Here we observed three males of *Orthetrum triangulare*. The dominant male was perched in the centre of this muddy spot, while the other two had to be content with positions along the edge of this microhabitat. When one female showed up, she was immediately grasped by the dominant male to form a mating couple, after which she deposited some eggs and vanished.

Location 2: 2 km before Bhatoli (30°30'03"N-78°01'02'E, elevation 1,220 m (Figure 2D).
Small mountain stream coming from steep forested slopes, completely shaded upstream by high and dense vegetation of bamboo, large ferns and shrub-like undergrowth of *Thalictrum, Solanum* and *Zingiber.* Near the road the stream descends over and through big rocks, creating natural 'stairs'. This part of the stream is sunny and open, with vegetation comprising only small ferns (*Adiantum*) and *Laportea* species. Some of the biggest rocks are partly covered with mosses and algae.
The first damselflies we found were four males of *Anisopleura lestoides* (Figure 3A), a common species of hill streams. All the males occupied a favourite perch on stones within their own territory. When a female appeared, a mating wheel with a male was formed and the pair disappeared in the dense vegetation, not to be seen again.

Most interesting was the behaviour of *Calicnemia doonensis* (Figure 3B), of which we discovered two pairs and one solitary male. We managed to observe one pair that was searching for a spot to lay eggs. The favourite

Figure 2. Study sites. (A) Location 1, cave. (B) Location 1, muddy place. (C) Figure 3 *Megalestes major*. (D) Location 2, stream near Bhatoli. Photo credits: D. Singh.

ovipositing sites of this species are the mosses growing on the shady side of the big rocks, where the mosses are kept soaking wet by the running, splashing water. Before finding a preferred moss patch, several others on the same rock are first investigated, the female meticulously testing the moss with her ovipositor, signalling to the male to move on if the site is deemed unsuitable. As far as we could observe, the eggs are laid between the moss fronds and not inserted into the moss tissue.

Around noon, two males of *Anisogomphus bivittatus* (Figure 3C) suddenly appeared, momentarily sitting and basking on the vegetation near the stream. As suddenly as they had appeared they also vanished, giving way for a female to dip some eggs into the stream.

Location 3: near Yamuna Bridge (30°30'556"N-77°59'046"E, elevation 673 m, Figures 3D and 3E).
Larger mountain stream with big boulders and stones, running through a deep valley, and originating from steep, forested, and shady hills. This stream flows into Yamuna River near Yamuna Bridge. Here, with nearby small human settlements, the stream is more open. Shortly before the stream reaches the Yamuna, some type of canal has been constructed to create a washing place for local use.

This mountain stream is also fed by numerous small streams, rivulets and trickles that pour down into the valley from the steep neighbouring slopes. Here we stayed for two full days to build up a good picture of the dragonfly fauna present.

In the sunny parts of the stream where the water rushes over and between the rocks, two species of damselfly seem to predominate: the incredibly beautiful *Neurobasis chinensis* (Figure 4A) and *Bayadera indica* (Figure 4B). Of the first, we counted 20 to 30 territorial males, of the second over 50 individuals over a distance of around 100 m.

The area with enormous rocks was also home to three species of jewels (Chlorocyphidae): *Aristocypha quadrimaculata* (5 males, 2 females, Figure 4C), *Aristocypha trifasciata* (2 males) and *Paracypha unimaculata* (1 male). Unsurprisingly, we also encountered *Anisopleura lestoides* (4 males), which was competing with *Neurobasis* and *Bayadera* for good perching sites.

On the second morning of our stay the weather was bright and sunny, attracting other beautiful

Figure 3. (A) *Anisopleura lestoides*. (B) *Calicnemia doonensis*. (C) *Anisogomphus bivittatus*. (D) Location 3, mountain stream near Yamuna bridge. (E) Location 3, mountain stream just before flowing into the Yamuna River. Photo credits: D. Singh.

dragonflies to this location. Between 10 a.m. and 2 p.m. we observed at least three different male *Macromia moorei* patrolling along the head stream and near the canal. These same places also proved appealing for four male *Anax immaculifrons* (Figure 4D) which often tussled in the air with the *Macromia* males.

The constructed canal, lacking big rocks and with dense, weedy vegetation on a substrate of gravel and small pebbles, seemed very appealing to certain gomphids. Here we observed *Anisogomphus bivittatus* (4 males, 2 females), *Nepogomphus modestus* (1 male) and *Scalmogomphus bistrigatus* (2 males).

The canal ends at the washing place, after which is a marshy area, just before the water runs into the Yamuna. This area is muddy, and with a dense vegetation of *Cyperus, Mentha, Xanthium, Rumex* and ferns, the water here is partly stagnant or flows down diffusely. This place was home for dragonflies favouring muddy and slow-running streams. Here we noted numerous species: *Trithemis festiva* (2 males, Figure 4E), *Trithemis aurora* (2 males),*Ischnura forcipata* (2 males), *Ischnura rubilio* (1 male), *Brachythemis contaminata* (1 male, 1 female) and several *Orthetrum* species: present each day were *Orthetrum glaucum* (5 males, 2 females, Figure 5A), *Orthetrum pruinosum* (2 males), *Orthetrum taeniolatum* (2 males, 1 female) and, in high numbers, *Orthetrum triangulare* (7 males, 3 females, Figure 5B). Here we also observed 10 males and 5 females of *Neurobasis chinensis*, 4 males of *Anisopleura lestoides* and 3 males of *Bayadera indica*.

In addition to this wonderful array of dragonflies we also discovered a small population of *Calicnemia eximia* (Figure 5C) along a trickle of a stream coming from the nearby rocks.

Threats

The area between Kempty Falls and Yamuna Bridge harbours a number of very valuable habitats for stream-dwelling dragonfly species. Location 3, in particular, is an example of an extremely rich mountain stream habitat; never before at any other location in Uttarakhand have we observed such a complete dragonfly assemblage. This habitat is under severe threat, however. We were told by local people that the government of Uttarakhand is planning a new hydro-electric project in the region, including construction of a new dam in the Yamuna

Figure 4. (A) *Neurobasis chinensis*. (B) *Bayadera indica*. (C) *Aristocypha quadrimaculata*. (D) *Anax immaculifrons*. (E) *Trithemis festiva*. Photo credits: D. Singh.

River nearYamuna Bridge.

Recent studies throughout the entire Himalayan range demonstrate that its odonate fauna is currently threatened by habitat destruction, not only as a result of hydro-electric projects, but also through deforestation for agricultural expansion, pesticide use, tourism and urban and industrial pollution (Subramanian & Babu, 2018). Despite the creation of several national parks and wildlife sanctuaries, there is an urgent need for the government of Uttarakhand to focus more on the protection of undisturbed freshwater ecosystems that are vital for the future of our beloved dragonflies.

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Figure 5. (A) *Orthetrum glaucum*, old male. (B) *Orthetrum triangulare*. (C) *Calicnemia eximia*. Photo credits: D. Singh.

Collecting dragonflies in Muskoka, Ontario, Canada

Dedicated to Gwendolin Irons

Jessica L. Ware [jware@amnh.org],
Patrick Hulick, and Syrus Ware

Over the last ten years (2010-2020), we have been actively sampling odonate biodiversity in Gravenhurst, on and around Lake Muskoka, but initially we were just sampling opportunistically while out for walks around our family cottage. Since 2015, however, we have been sampling in a systematic fashion, to document in earnest the biodiversity on and around Lake Muskoka. Our sampling team has varied over the years, but usually involved 2-4 adults, and 2-3 enthusiastic children (whose sampling skill has increased with time). In terms of nets, we used either bioquip student nets, or Rose entomology nets. Sampling took place for several hours twice a day, and then again at dusk. Sampling took place in 2015, 2016, 2017, 2018, and 2019 (June, July and August).

Sampling team

One of the adults on the collecting "team" is my Nan, Mrs Gwendolin Irons, 94 years of age, who took up dragonfly hunting in 2003 when author Jessica Ware was in graduate school (Figure 1A). Equipped with a net, Gwen would readily swing at any odonates landing in her garden, or on the verandah, where she and Ware's late grandad (Harold Irons) would sit most days. Interestingly, the place where we sampled was land that Harold Irons' father, Philip Irons, purchased after he moved to Canada from England at the start of the 20th century. He was a costermonger and would sail his boat, the Izaak Walton, to islands selling produce and other groceries (Figure 1B). He sold the land and it was later bought back by Gwen's family. The Irons built a winterized house on the property in the late 1970s, and we (Syrus and Jessica) spent much of our childhood there observing odonates from the dock or while sitting on the verandah.

Figure 1. (A) Mrs. Gwen Irons and Jessica Ware, Lake Muskoka. (B) Philip Irons's boat, the Izaak Walton, on Lake Muskoka.

Sampling Location

Lake Muskoka lies ca. 180 km north of Toronto, a glacial lake that is on part of the southern range of the Pre-Cambrian shield's Laurentian highlands (latitude: 45.031863, longitude: -79.447524; Atlas of Canada). The lake is 89 km^2, with ca. 178 islands, tree lined shores, and sandy substrate. Several have documented the Odonata of Canada with an emphasis on Ontario (e.g. Walker, 1911; Walker, 1953; Walker, 1958; Walker and Corbet, 1973; Skevington and Carmicheau, 1997; Catling *et al.*, 2002; Catling, 2005). Beatty *et al.* (2010) recorded 134 species of Odonata in Ontario, noting that several species changed in their abundance over the time period they studied (1950s and 2002). We found several of these 134 Ontario species at our sites, but not all species have ranges in Muskoka. Muskoka species biodiversity seems to closely overlap with the shorter list of 82 species list from Thunder Bay, Ontario (Checklist of the Odonata of Thunder Bay District, March 2010; Walker, 1924) and the list from Georgian Bay (Walker, 1911).

Our sampling sites included (a) our tree lined property directly on Lake Muskoka, approximately 7 miles outside of Gravenhurst, (b) a forested area with several marshes (hereafter called the first and second marsh) and sloughs, and (c) the barrens by Torrence, approximately 16 km outside of Gravenhurst (Fig. 2, sites A, B, C; interestingly, these exact barrens were featured in Lucy Maud Montgomery's book, "The Blue Castle"). Sampling was done from the shoreline of the lake and marshes, as well as in the forested surroundings.

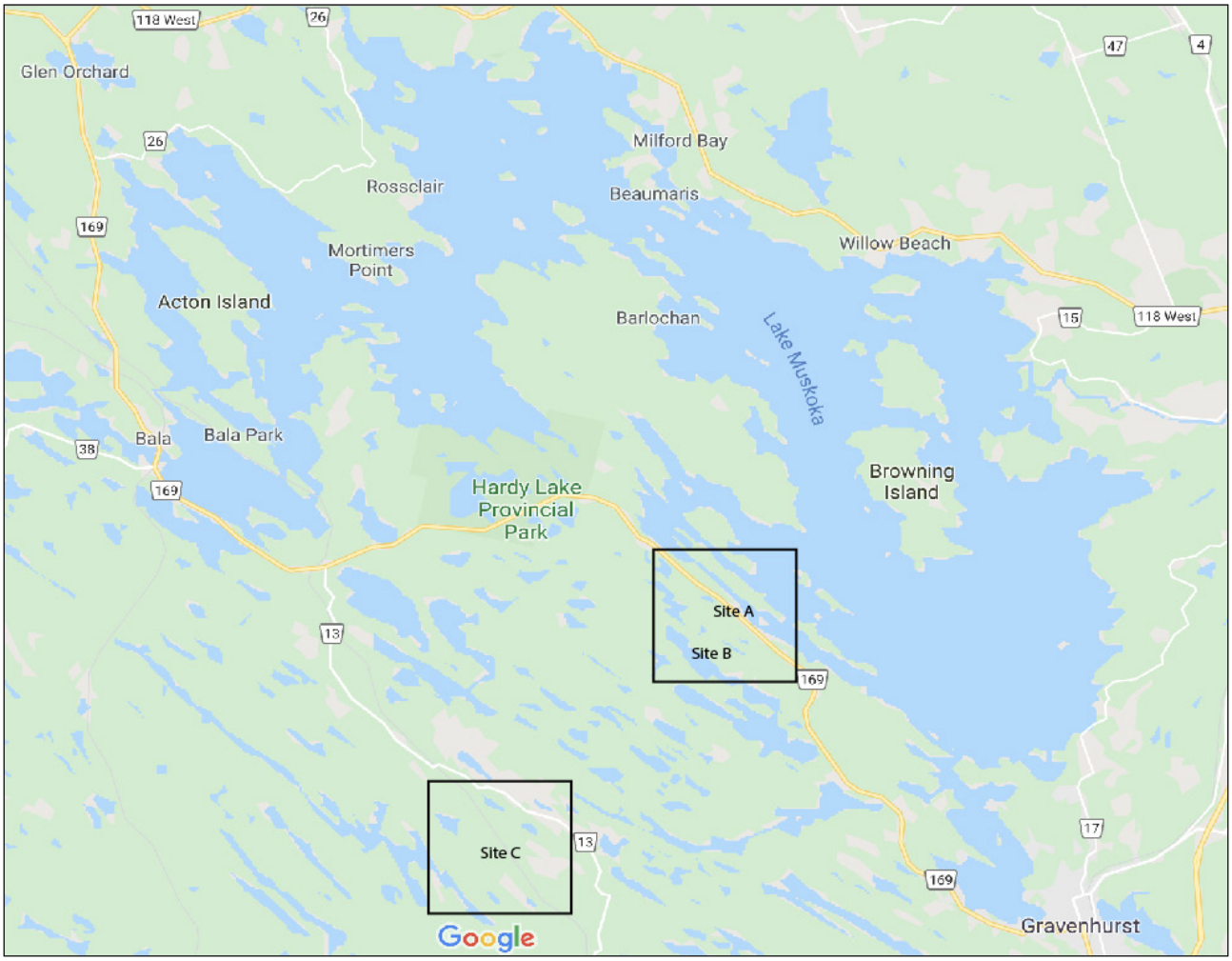

Figure 2. Sampling localities: Lake Muskoka, first & second marsh, Torrance Barrens.

Sampling Conditions

Synonymous with "Ontario summers" are "biting flies". While sampling along the marshes, and in the forested areas or the barrens, we strongly felt as Wade Hemsworth sung in his 1949 song, "the blackfly song",

> 'Twas early in the spring when I decided to go
> To work up in the woods in North Ontario……
> And the black flies, the little black flies
> Always the black fly no matter where you go
> I'll die with the black fly a-pickin' my bones'.

We experienced harsh blackfly clouds when sampling in the earlier part of the summer, followed by deer fly and horsefly clouds during the July and August months. When collecting Corduliidae in the evening, mosquitos were so numerous that we kept our mouths closed to avoid them flying in when taking a breath or speaking.

Sampling Results

We commonly collected odonates from about 9 AM through 8:30 PM in the evening, with the peak time being between 10 AM and 2 PM. Individuals were commonly seen perching on juniper bushes in forest areas, and on the sides of the boathouse or dock on the lake. At the first and second marshes we most commonly collected samples that were patrolling the shoreline, or individuals that landed on rock outcroppings (Figure 3A-F). Several taxa were common (Table 1).

Certain taxa were more common near the marshes, such as *Williamsonia*, *Hagenius*, *Somatochlora, Celithemis*, *Anax,* and *Nannothemis*. Others were collected daily on the rocky outcropping by Lake Muskoka: *Aeshna, Leucorrhinia, Dorocordulia*, *Ladona, Libellula, Plathemis, Pachydiplax, Neurocordulia.*

We have been doing mark and recapture sampling for several species to estimate population sizes over the last three summers. Sadly, we will not be able to continue our work this summer if the lockdown due to the


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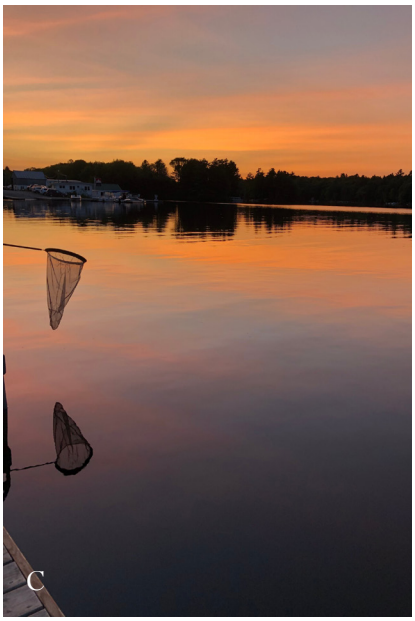
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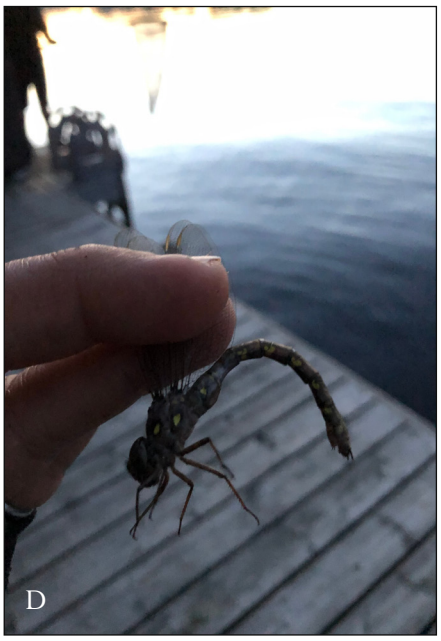
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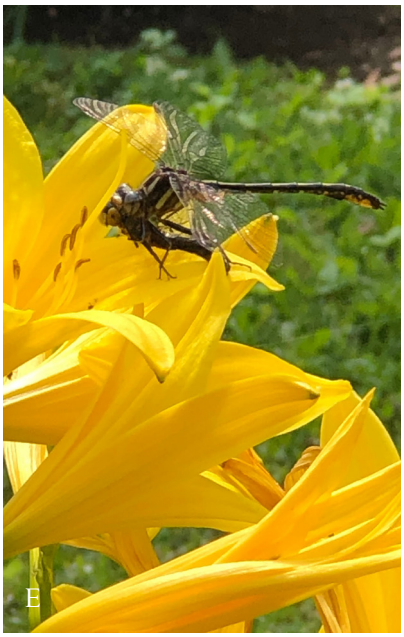
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Corona virus continues. Our ultimate goal is to characterize the biodiversity of the Muskoka Lakes region, at the population level. This is a lofty endeavour, as estimating population size for dozens of species is time consuming, but we hope this will be good baseline data in an ever warming climate during a time of predicted insect decline.

Acknowledgements
We thank Aeshna Ware Huff, Amelie Ware Redman and Zack Ware Huff for collecting assistance. We thank David Curtis and David Irons for granting access to the first and second marsh.

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Figure 3 (page 126). (A-B) Collecting along the first marsh. (C) Sunset on Lake Muskoka, hunting Corduliidae. (D) *Boyeria*, collected on shore of Lake Muskoka. (E) Gomphid in Gwen Irons' garden, Lake Muskoka. (F) Gomphid exuvia between slats of the dock on Lake Muskoka. (G) Younger members of sampling team hunting in typical Muskoka forest habitat. (H-I) Collecting on second marsh.

Table 1. Species found in this study, across sampled years

Family	Taxon	Location	Sampling date range
Aeshnidae	*Aeshna canadensis*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Aeshnidae	*Aeshna interrupta*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Aeshnidae	*Aeshna juncea*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Aeshnidae	*Anax junius*	1st and 2nd marsh, Torrance Barrens	Mid June-late August
Aeshnidae	*Basiaeschna junata*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-mid July
Aeshnidae	*Boyeria grafiana*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	July
Gomphidae	*Arigomphus villosipes*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Gomphidae	*Gomphus* sp.	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Gomphidae	*Hagenius brevistylus*	1st marsh	Mid June-late August
Gomphidae	*Ophiogomphus colubrinus*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Corduliidae	*Cordulia shurtleffii*	1st and 2nd marsh	Mid June-late August
Corduliidae	*Dorocordulia lepida*	Lake Muskoka	Mid June-late July
Corduliidae	*Epitheca cynosura*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-mid July
Corduliidae	*Epitheca princeps*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-mid July
Corduliidae	*Epitheca spinosa*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-mid July
Corduliidae	*Neurocordulia yamaskanensis*	Lake Muskoka	Last week June-first week August
Corduliidae	*Somatochlora* sp.	1st and 2nd marsh	Mid June-mid July
Corduliidae	*Williamsonia fletcherii*	1st marsh	Mid June-mid July
Libellulidae	*Celithemis elisa*	1st marsh	Mid June-mid July
Libellulidae	*Celithemis fasciata*	1st marsh	Mid June-mid July
Libellulidae	*Erythemis simplicicollis*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Libellulidae	*Ladona julia*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late July
Libellulidae	*Leucorrhinia frigida*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late July
Libellulidae	*Leucorrhinia intacta*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late July
Libellulidae	*Libellula incesta*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Libellulidae	*Nannothemis bella*	1st marsh	Mid June-late August
Libellulidae	*Pachydiplax longipennis*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Libellulidae	*Perithemis tenera*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Libellulidae	*Plathemis lydia*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August
Libellulidae	*Sympetrum internum*	Lake Muskoka, 1st and 2nd marsh, Torrance Barrens	Mid June-late August

"Students odonatin' in a foreign land": A recap of 2019 Vanuatu fieldwork

Daniel G. Ferguson [danferg21@gmail.com], Natalie A. Saxton & Seth M. Bybee

Introduction: It started fast

In the early spring of 2019, our study abroad group composed of 14 individuals made its way to the island nation of Vanuatu specifically to study an endemic genus of damselfly, *Vanuatubasis* Ober and Staniczek. With our professor (Seth Bybee) in tow, four graduate students and nine undergraduates, we had the goal of doing fieldwork on five different islands. For many of the students, this would be their first-time doing fieldwork--- a seven week, intensive research trip on an island archipelago in the South Pacific. Needless to say, as students we were both nervous, and excited for the adventures ahead of us. Our first couple of days were spent on the island of Efate (Figure 1) clearing up visas, getting permits, relaxing on the beach, and collecting insects close to our hotel while we waited for our flight to the next island, Malekula.

Malekula is the second largest island in Vanuatu after the island of Espiritu Santo. Malekula is best known for its coconut farms, high mountains, and its history of cannibalism (Cheesman, 1933). After spending a few days on Efate with no sightings of *Vanuatubasis*, Malekula with its abundance of rivers and streams, galvanized us as we searched for our target odonate.

As we made our way to the first stream, many of us were unsure what to expect having only heard stories and read about fieldwork and having virtually no experience walking through rivers in search of a dragonfly we had never seen in the wild. The day immediately started off as a success, but not in the way that we had expected, as one of our first catches was not a *Vanutubasis* at all but rather a female *Melanesobasis* Donnelly! This genus, almost exclusively known from Fiji, had only been collected in Vanuatu one other time on the island of Maewo (Donnelly, 1984). Most of our morning was spent trekking through a crystal clear river system that cut through a beautiful, lush, green forest ecosystem catching odonates such as *Pseudagrion microcephalum* (Rambur, 1842) and *Agriocnemis exsudans* Selys, 1877. Most of the dragonflies we were catching were right off the river. However, as most of us were new to this, we soon learned our mistake. Seth was soon victorious, in his net, a beautiful *Vanuatubasis.* It turns out *Vanuatubasis* tend to stay off the water, preferring to spend their time in shaded areas while perched on trees or ferns. This behavior makes them difficult to spot as they blend in remarkably well. As we adjusted our technique, many of us were able to net a few *Vanuatubasis* specimens throughout the day.

Malekula was very fruitful in terms of *Vanuatubasis,* and we collected specimens from various localities around the island. The diversity of *Vanuatubasis* on Malekula was hard to sort out as the overall appearance was very similar with most specimens varying slightly in blue to green coloration, with a few darker individuals. We did notice that there was some significant size variation between streams along with some behavioral differences as well. For example, on one stream *Vanuatubasis* was less common, more cryptic and solitary while on a stream a few kilometers away, the species was larger, more gregarious and much more common. We thought this might be due to the numbers, but the size difference made us think perhaps this was a difference between species. Malekula turned out to be a great place to learn how to catch dragonflies, and better understand the habitat of *Vanuatubasis.* We were also able to confirm previous sighting from years ago,

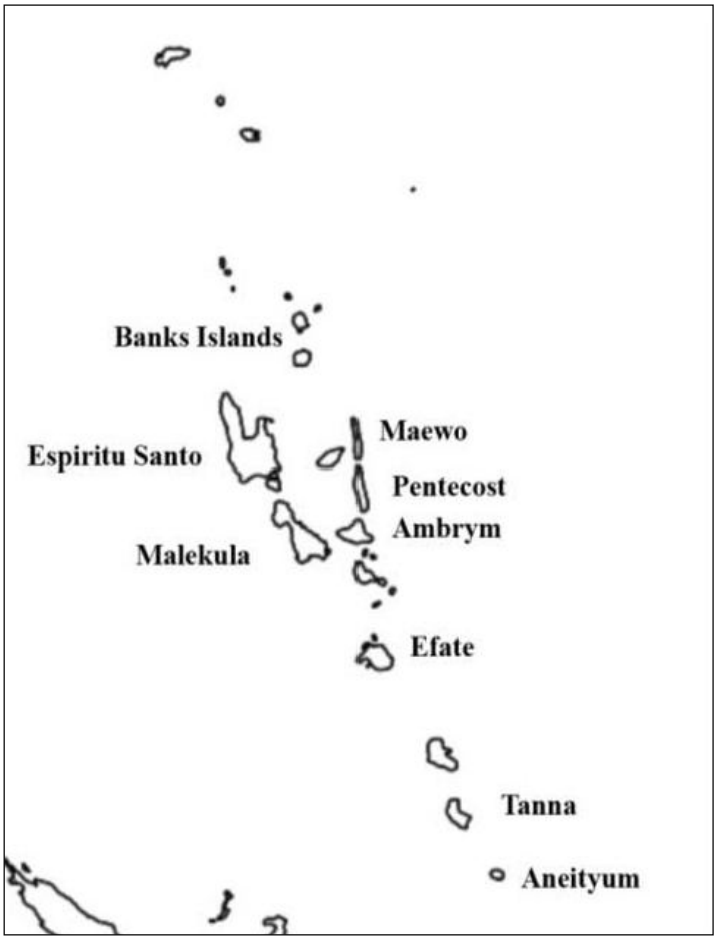

Figure 1. Map of Vanuatu. Made using Simplemapper (Shorthouse, 2010).

and feel a connection with scientists that once traveled these rivers many years ago, such as Evelyn Cheesmen. Cheesman traveled to Malekula in the mid-20th century, against the wishes of her male colleagues, making history as the first white individual to access many locations around Malekula, as well as other islands throughout the region (Touzel and Garner 2018). In doing so, she became a prominent figure in South Pacific entomology and biogeography, a legacy that still stands strong to this day.

Our lows took us higher

Ambrym

After a good deal of success on Malekula, many of us felt that we had the training we needed to be more independent and were ready to hit the ground running on our next island, Ambrym. The moment we landed on Ambrym, we could tell this island was different. The dirt was a black color, and beaches were lined with black lava rocks. The island is home to an active volcano, one of the most active in the world. The volcano itself brings travelers from around the world because of the large lava lake that is exposed. Sadly, due to an earthquake in December 2018, the lava has recently disappeared, and while we did hike to the very top of the volcano, we were not able to see the lava lake. Nevertheless, the island was beautiful and we were ready to start collecting.

Unlike Malekula, where we found success at every turn, Ambyrm did not start off successfully, nor did it really end up being successful in terms of finding *Vanuatubasis*. We spent many of our days there in the rain and often returned to our bungalows with only a handful of dragonflies, none of them our targets. Even on days when it wasn't raining, we had difficulty locating rivers and streams as they are fairly isolated and hard to access and the locals told us there were not many streams nearby. The locals on Ambrym survive largely on rainwater.

We didn't find much water until we started our hike up to the volcano. We made sure to take our nets with us on the three to four hour long hike just in case we saw some dragonflies along the way. It wasn't until we gained some serious elevation and were hiking through the lush forest of Ambrym that we started to see small creeks and puddles. At this point we became more hopeful of seeing *Vanuatubasis*. As we started seeing the appropriate *Vanuatubasis* habitat of streams with ferns up the side of the rocks, we slowed our pace and started tapping the ferns in hopes of seeing these nearly invisible damselflies take flight. It wasn't long until we started seeing slow movements among the shadows and began netting some damselflies. However, these were not the odonates we were looking for. In our nets we found *Indolestes* Fraser, 1922, which are slow moving, darkish damselflies that seem to be found in a similar habitat as *Vanuatubasis*. We can't confirm the identification of this species since we do not have lab access at the moment. The rest of our hike to the volcano was spent looking for *Vanuatubasis*, with no luck.

However, luck changed a little bit in terms of different habitats when we got a view of the volcano. As we left the greenness of the jungle, we passed an open dirt area, which soon became an open ash field. The environment was changing right before our eyes. As we kept moving, the ash covered ground showed signs of life with moss covering much of the area around us (see Figure 2). Honestly it felt like we were on another planet, it was absolutely beautiful. We hiked to the top of one of the volcanoes, and we are able to see inside and even walk along the rim. We were all a little sad we didn't get to see the lava lake, but it was still amazing.

In terms of dragonflies, specifically *Vanuatubasis*, Ambrym was a disappointment. However, it opens up some potentially great biological questions. Why didn't we find any *Vanuatubasis* on Ambrym even though our models predicted they would be there? We noticed that the island itself seemed cooler than Malekula, is it possible that they are more active during a different time of year? Does the relative lack of water have something to do with it? Is it the volcano? Were we in the wrong place to collect them? Or, was it just the weather? Overall, our time on Ambrym brought up some interesting questions that further intrigued us when we visited other islands without the genus. Future work on this island may help to answer some of these lingering questions.

Figure 2. A group of students looking back at the path they have taken on their way to the volcano.

Tanna

Like Ambrym, Tanna has a famous active volcano named Mt. Yasur. Tanna is a more popular place to view an active volcano, and sees many more tourists visiting the island, as you can drive most of the way up it. Unlike Ambyrm's volcano, Tanna's Mt. Yasur has lava that can be seen exploding from the top (even from a distance when it's dark enough). When you spend time on that side of the island you can even periodically hear the volcano rumbling. We got to see the volcano and the erupting lava (see Figure 3). However, the rest of our time on Tanna was spent searching for dragonflies. We had better weather for most of our time on Tanna, although being significantly further north than some of the other islands it was a bit cold.

Figure 3. A group of students on top of Mt. Yasur watching the erupting lava.

We got a variety of odonates including: *Agriocnemis exsudans, Pseudagrion microcephalum, Indoletes* sp., *Anax guttatus* (Burmeister, 1839), *Diplacodes* sp. Kirby, and *Pantala flavescens* (Fabricius, 1798) to name a few. Though we had perfect habitat for *Vanuatubasis,* we again came up empty handed. This is in spite of the fact that we were able to move around quite easily on Tanna due to comparatively good roads. Just like on Ambrym, we found *Indolestes* in habitats where we would expect to find *Vanuatubasis*. The patterns and questions that came about on Tanna, were similar to Ambrym. Why are we not finding *Vanuatubasis* on these islands? However, another variable that Tanna adds is more human activity and infrastructure compared to Ambrym. Tanna was by far the most impacted island we worked on. It also seems strange that Tanna does not have *Vanuatubasis* when an island even further south, Aneityum, does. Again, there are some interesting scientific questions that would be fun to investigate further. Our lab plans to do these investigations as we eagerly look forward to returning to Vanuatu and other surrounding island groups.

Odonating on new ground

Maewo and Pentecost were the islands we were perhaps most excited to visit. These islands are next to each other, and share a very similar geological history and together make up the eastern most portion of Vanuatu. The last time a dragonfly was collected on Maewo was likely back in the 1970s, while on Pentecost there is no record of dragonflies ever being caught. We entered these islands with a lot of unknowns, which made it that much more exciting! As mentioned previously, we had generated computer models for the presence of *Vanuatubasis* across Vanuatu and the predictions of *Vanuatubasis* on these islands were very strong.

Maewo

On the way to our accommodation from the airport we passed river after river, and waterfall after waterfall. It was clear our models had been correct and this place would be special. The sheer number of streams on this island was incredible. Maewo started off as a race. Who would be the first to catch an odonate on this island for the first time in nearly 50 years? The race didn't last long, one of us netted a dragonfly rather quickly, by this time we were all pros. It also didn't take long for us to find *Vanuatubasis* scattered throughout the rivers.

Maewo turned out to be unique in the amount of water we found on the island, as it seemed to be everywhere. A short walk in any direction seemed to lead you to some body of water, which made collecting odonates rather simple. Most of our days on Maewo were spent walking along the roads that run north and south along the coast until we reached a river or stream. Everytime we reached water, we would hike up several kilometers, collect as we went and then move on to more water. Since our time on Maewo was relatively short, this quick collecting method worked well for us as we were also able to collect a diversity of dragonflies along the roads, but also hike up many rivers and streams to collect different types of dragonflies, including *Vanuatubasis.* Although we were able to get good coverage of Maewo, we really want to make sure we get deeper into the jungle during our next visits.

Most days on our way collecting we would pass a wide river with several small waterfalls that could be seen from the road. This river certainly had *Vanuatubasis,* and we were saving it for a day that we needed to stay close to our accommodations. We heard from the locals that there was a very large waterfall not too

far up this river as well. We knew we *needed* to collect on this river. The river ended up being among the most memorable of the entire trip. We collected many *Vanuatubasis,* but we also saw beautiful waterfalls. It seemed every 20 or 30 minutes we would find another waterfall, and they were all beautiful. However, the large one the locals were talking about, was truly magnificent (see Figure 4). It was an immense waterfall that must have risen several stories above where the water actually fell to the main river. lt was also quite wide, perhaps half a football pitch wide, and powerful. The water ran swiftly over the top of a limestone base but was only about 20–25 cm deep. What made it unique was that you could walk up the waterfall and get to the top, which we obviously had to to do. We collected several specimens along the edges of this waterfall. Collecting up top was great as well, we were able to snag some more *Vanuatubasis* and get an even better view of Maewo. However, it also turned out to be dangerous as there were random pits along the shores of the river, in which we almost lost Seth. He fell right into one while collecting, but managed to catch himself at the shoulder on the edges of the pit. He did not touch the bottom and we were all relieved he didn't find the bottom as the current of the river was quite strong. With collecting done for the moment, we decided the best way to get off the waterfall would be to jump 9 meters or so off the waterfall. It was a spectacular way to end the day. But at least one student did lose water shoes due to the force of impact. We also explored behind the waterfall finding extremely large crabs.

Figure 4. Our students in front of the waterfall on Maewo.

We came into Maewo with high hopes, many of which were exceeded. Collecting on this island was great, and we think this island will be key to help us understand the evolutionary history of *Vanuatubasis* throughout Vanuatu.

Pentecost

Pentecost had a very similar feel to Maewo, but with a little more excitement. According to Marinov et al. (2019). Pentecost had never been sampled. Dragonflies collected on this island would be recorded on Pentecost for the first time, and this made Pentecost special, especially if we could find *Vanuatubasis.* Finding *Vanuatubasis* came relatively quickly as they could be found in many places, but not as abundantly as on Maewo.

Searching for *Vanuatubasis* on Pentecost wasn't always easy and sometimes the rivers didn't match our idea of typical *Vanuatubasis* habitat, but we searched anyway. After more than an hour of walking through a wide, fast moving river the locals call the "white river" due to its white color (we found it to have a relatively high pH) we noticed water seeping from steep cliffs above us. The seeps ran for ~125 yards up the side of the cliff and made for even better habitat for *Vanuatubasis* being covered in ferns and overhanging vegetation. So we hiked our way up. Though the climb up these seeps was rather difficult, we were rewarded with *Vanuatubasis.* Needless to say we were excited! As we searched for more seeps, we were rewarded with more *Vanuatubasis,* and we were able to find a single *Melanesobasis* male specimen as well. As excited as we were for the research success we were having on Pentecost, it still may not have been our favorite part.

Pentecost allowed us to build some of the greatest relationships with the local people. There were days when we had some of the local kids help us collect, and on these days we always collected more, as they had an amazing ability to spot everything. We also had a great opportunity to learn about the local culture on Pentecost, as we lived in the village and interacted with the friendly locals.

The local custom of land diving happens to be one of the main reasons that Pentecost has tourists at all. And we must say the custom is both mesmerizing and hair raising all at the same time. During May and June there is a custom of jumping from high towers with vines tied to one's feet to bless the yam harvest. The goal is to brush one's head against the ground from dizzying heights (but not die…the first rule of the jungle). It made for extremely breath-taking moments and many of us are unsure if we would ever want to watch it again. While the villagers, dressed in local attire sang traditional songs, clapped and danced, we watched in awe as jumpers (8 in all) leapt, starting from 6 m all the way up to >41 m (see Figure 5).

Following our time in Pentecost we returned to Efate to get export permits and wrap up the trip. We had

additional success collecting *Vanuatubasis* there as well. It appeared to be distributed in rivers all along the coast. Although after six weeks on remote islands it felt like returning to the big city and it was hard to appreciate it, even with its modern luxuries, as we did on our first days on the island in late April.

Conclusions

Through our time in Vanuatu, we collected new *Vanuatubasis* species. In fact, Natalie and Danny are working on a project to explore more about their taxonomy, systematics and evolutionary history. Even though we didn't catch *Vanuatubasis* on all the islands we visited, this provides exceptional scientific questions and a need to return, which we are not sad about. What is different about Ambrym and Tanna that we are not able to find *Vanuatubasis* on those islands? Will the time of year affect when this genus can be collected on certain islands? These questions are what will be bringing us back to Vanuatu again, and again.

What really needs to be said is that the people of Vanuatu are some of the most loving and kind people we have ever encountered. We are truly grateful for their hospitality over our seven week stay in Vanuatu, their kindness towards us will never be forgotten.

Figure 5. Seth with the local Chief (dressed in local attire) in front of the tower.

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Strong changes in Dutch dragonfly fauna

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Many species of dragonflies are restricted to specific habitats and sensitive to changes in their habitat. This means that the occurrence of different dragonfly species can be indicative of changes in the environment. Often this is a decline as a result of habitat deterioration and dragonflies are under environmental pressure due to anthropogenic impacts (Clausnitzer et al. 2009). Because dragonflies are very mobile, many species are able to recolonize areas after habitat quality has sufficiently recovered again. We have seen this for a number of species in Europe and it has been previously described for the Netherlands due to the restoration of water quality by Termaat et al. (2015). The dragonfly fauna is however highly dynamic and much has happened since.

Distribution trends

Thanks to the large number of citizen scientists the Dutch dragonfly fauna has been relatively well studied, with over 3.2 million records for a country of less than 34,000 km^2. This allows us to calculate trends in population distribution using occupancy modelling. Occupancy models separate occupancy (presence of a species at a location) from observation by taking imperfect detection into account (van Strien et al. 2013). This way we can estimate in which km-squares a species was likely present in each year since 1991. Doing this for all years we can calculate trends in distribution over time. Within the Dutch Network Ecological Monitoring (NEM) these distribution trends are calculated annually.

Tim Termaat et al. (2015) showed that dragonflies strongly recovered in the Netherlands in the period 1991-2013. In this study we give an update of the trend up to 2019 and by distinguishing three species groups based on habitat we try to analyze the potential drivers behind the overall and species group specific trends: 1) species preferring brooks, streams, and rivers (hereafter 'running waters'); 2) species preferring oligo- to mesotrophic and acidic standing waters mainly fed by rain water, such as moorland pools, shallow soft-water lakes and bogs (hereafter 'moorland pools'); 3) species preferring meso- to eutrophic and alkaline standing waters mainly fed by ground water, such as fens and lowland peat mires (hereafter 'fens'). Seven species (*Aeshna grandis*, *Cordulia aenea*, *Lestes sponsa*, *Libellula quadrimaculata*, *Orthetrum cancellatum*, *Pyrrhosoma nymphula*, and *Sympetrum vulgatum*) occur optimally in both moorland pools and fens. In the Netherlands, the moorland pools are separated geographically from the fens (located respectively in the low, western part and high, eastern part). This makes it possible to calculate a trend for both habitat types for these species.

Running water

Up to 2013 there was a clear overall increase in the distribution of dragonflies in the Netherlands but not equal for all groups (Fig. 1). The strongest increase was for species living in running water such as *Calopteryx virgo*, *Erythromma lindenii* and *Gomphus vulgattissimus*. The recovery for species of fens and species of moorland pools showed much less of a recovery. The improved water quality, by large scale purification and other measures due to stricter regulations, payed off in running waters and dragonflies were able to recolonize the recovered, now suitable habitats. In the other two species groups the effect on the recovery was slower, likely as most of these species depend on vegetation structures that recover more slowly.

As we have updated the trends discussed in Termaat et al. (2015) with the data from the last decade it becomes clear that the increase in the distribution of running water species has come to a standstill. We think that this is due to the stabilization of the improvement of the water quality. In theory, a recovery can also come to a standstill as all potentially suitable habitats are occupied. This does not seem to be the case. Most species of running water are still relatively rare and there are many streams and small rivers that are not occupied yet. It is likely that in many locations the habitat quality is still too poor for these species, e.g. insufficient water quality.

Fens and lowland peat mires

Species of fens continue to increase with a moderate pace. If we look at individual species, we can see that *Aeshna isosceles*, *Brachytron pratense* and *Libellula fulva* have become much more widespread over the last decades (Fig. 2). They were typical species for fen ecosystems but have spread to other areas as well and now occur outside fens in areas where well-developed aquatic vegetation with emergent plants such as reed is present. This might partly be an overshoot of the growing populations in the fen areas but might also be a result of improved water quality and habitat restoration resulting in more suitable vegetation in the rest of the country.

Some of the more critical species, those that are limited to nature reserves, also seem to be expanding their distribution lately. *Somatochlora flavomaculata* has increased its distribution and continued to do so in the

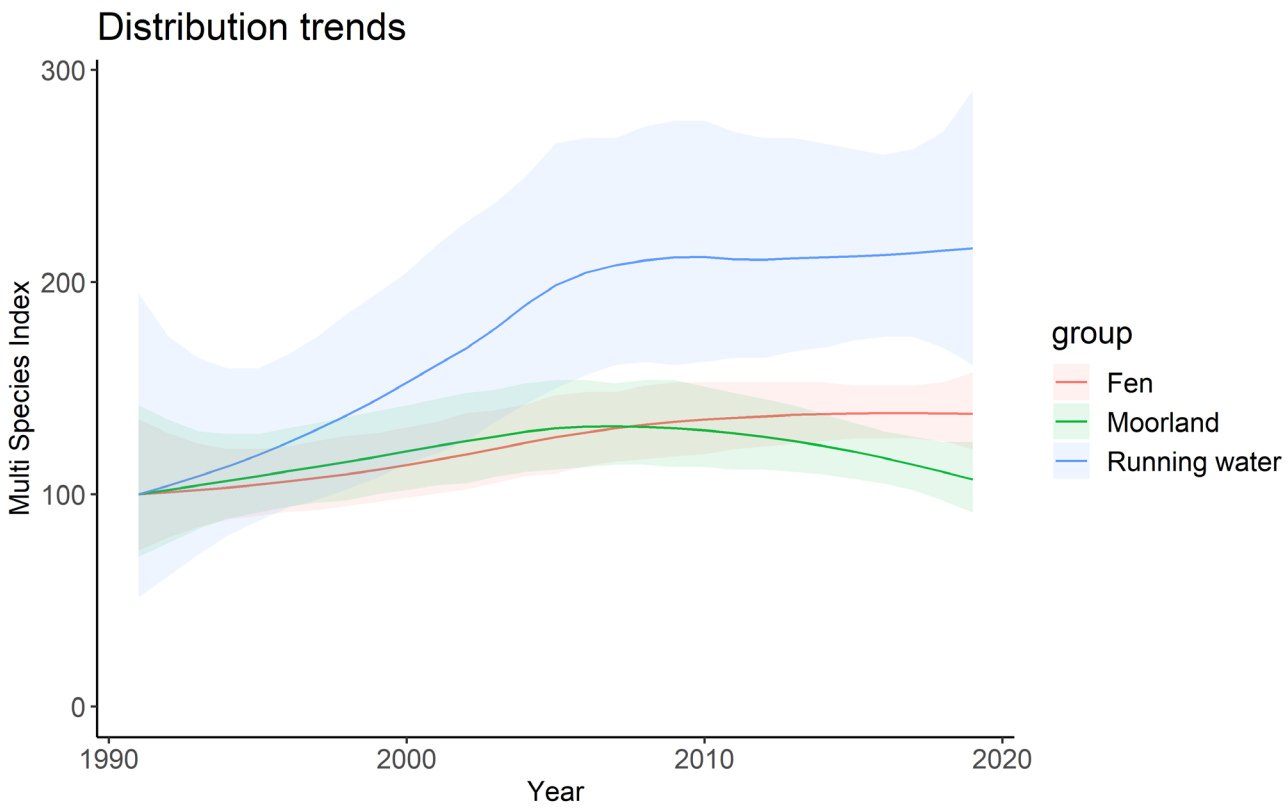

Figure 1.The multi species indices for dragonflies of the different habitat types (smoothed trend and 95%CI)

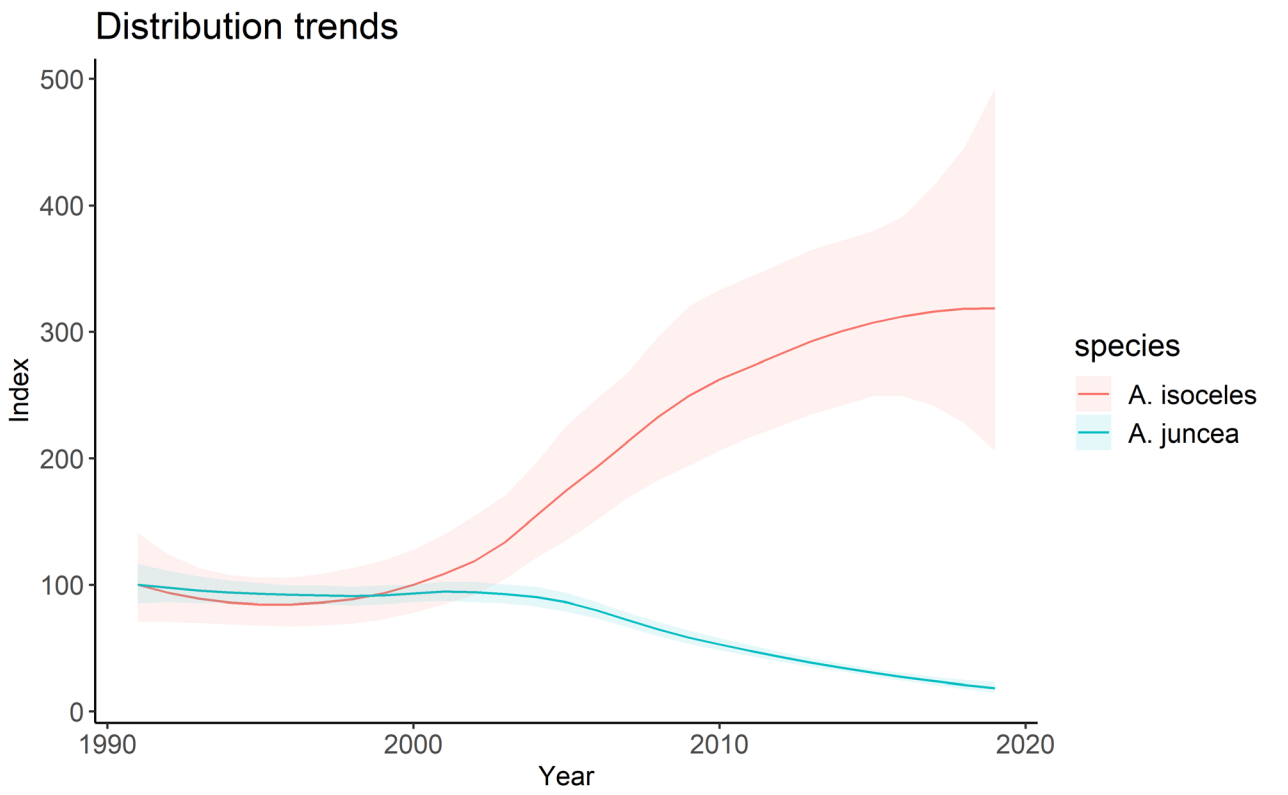

Figure 2. *Aeshna juncea*, a typical species of moorland pools and A. isoceles, a species common in fens and more buffered ecosystems, have strongly contrasting trends (smoothed trend and 95%CI).

last decade. Most spectacular however is the return of *Leucorrhinia caudalis*. This species went extinct in the Netherlands in 1970 and was very rare in the surrounding countries. In 2006 two animals were seen in the far south of the country but no population was estblished at that time. In 2009 another animal was seen in the north of the country, in a fen area. The numbers slowly increased in the following years and surrounding areas were colonized until in 2018 they appeared in locations scattered over the country (van Grunsven & Bos, 2019). Meanwhile they had become the one of the most abundant dragonflies in the area they colonized first, with a population that must run into the tens of thousands.

Moorland pools and bogs

The dragonflies of moorland pools do however show a very different pattern than described by Termaat et al. (2015). The reduction of acidifying deposition and eutrophication and the numerous habitat restoration projects have helped the recovery of this group of species. Some typical but common heathland pool species were declining in abundance, e.g. *Enallagma cyathigerum*, *Lestes sponsa* and *Sympetrum danae*. These can be very abundant on acidified pools and their decline was thought to be the result of reduced acidification and improved water quality (Nederlandse vereniging voor libellenstudie, 2002). At that point, there was a slight decrease in the distribution of these species but that was well within the uncertainty. Their decline was therefore considered a good sign in Termaat et al. (2015). This decline has however continued since 2013 and, as can be seen in Fig. 4, has become quite substantial. This seems puzzling. *Sympetrum danae* and *Lestes sponsa*, previously a common dragonfly and damselfly of nutrient poor acidic standing water such as moorland pools, have lost large parts of their distribution in the Netherlands. If the habitat would have improved, less acidified, they would have become less dominant but not disappear completely from many locations.

Figure 3. *Aeshna juncea*. Photo credit: Antoine van der Heijden.

If the decline of these acidophilic species was the result of improved water quality, we would also expect an increase of the more critical species that should be able to recover. We see the opposite, however: more critical species that are typical of moorland pools, *Coenagrion hastulatum*, *C. lunulatum*, *Aeshna juncea* (Fig. 3), *Leucorrhinia dubia* and *L. rubicunda* all show declines over the last ten years from 3% per year for *L. dubia* up to 10% decline in distribution per year for *A. juncea*. The current distribution of *A. juncea* is only 15% of that in 1991 (Fig. 2). The cause of these worrying declines is unknown. In 2018 and '19 the summers were very dry and this had an extra negative impact as many of these rainwater dependent pools dried completely or partially. In the fen ecosystems this was less problematic as the water levels in the low lying parts of the Netherlands are strongly controlled (for agriculture). Many populations of *C. lunulatum*, *C. hastulatum* and *A. juncea* have probably been lost as a result of these droughts. However, the decline started before these droughts so this cannot be the sole cause. The heathland pools and peatbogs habitats, and the accompanying typical dragonfly species, are of colder climates. These habitats are at the southern border of the distribution range in the Netherlands or restricted to higher altitudes further south in Europe. So climate change is likely making the Netherlands less suitable for these species and possibly unsuitable in the (near) future.

Climate change

The increase of thermophilic species is well known and is also obvious in the Netherlands with increasing numbers of *Coenagrion scitulum*, *Anax parthenope*, *Sympetrum meridionale* and *Crocothemis erythrea*, previously extremely rare species. As indicated above it is possible that climate change also drives the decline of moorland pool species. For every species it is possible to calculate a value indicating the temperature preference based on the annual average temperature in the areas where it occurs, called the Species Temperature Index (STI) (Termaat et al. 2019). If climate change is an important factor we would expect a relationship between the STI and the trend, with the species with a low STI showing negative trends. This is exactly what we see over the last 10 years (Fig. 5). All

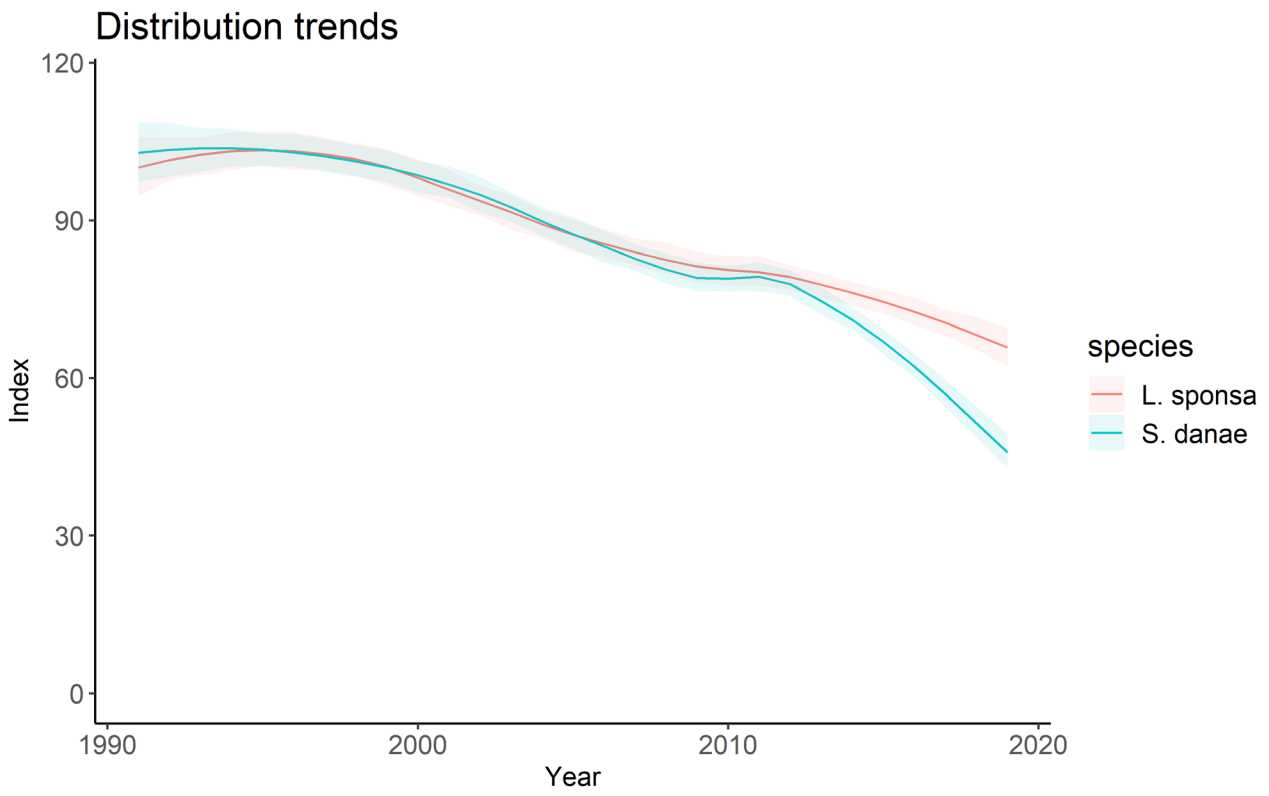

Figure 4. The species *Lestes sponsa* and *Sympetrum danae* used to be very common in moorland areas but have declined substantially (smoothed trend and 95%CI).

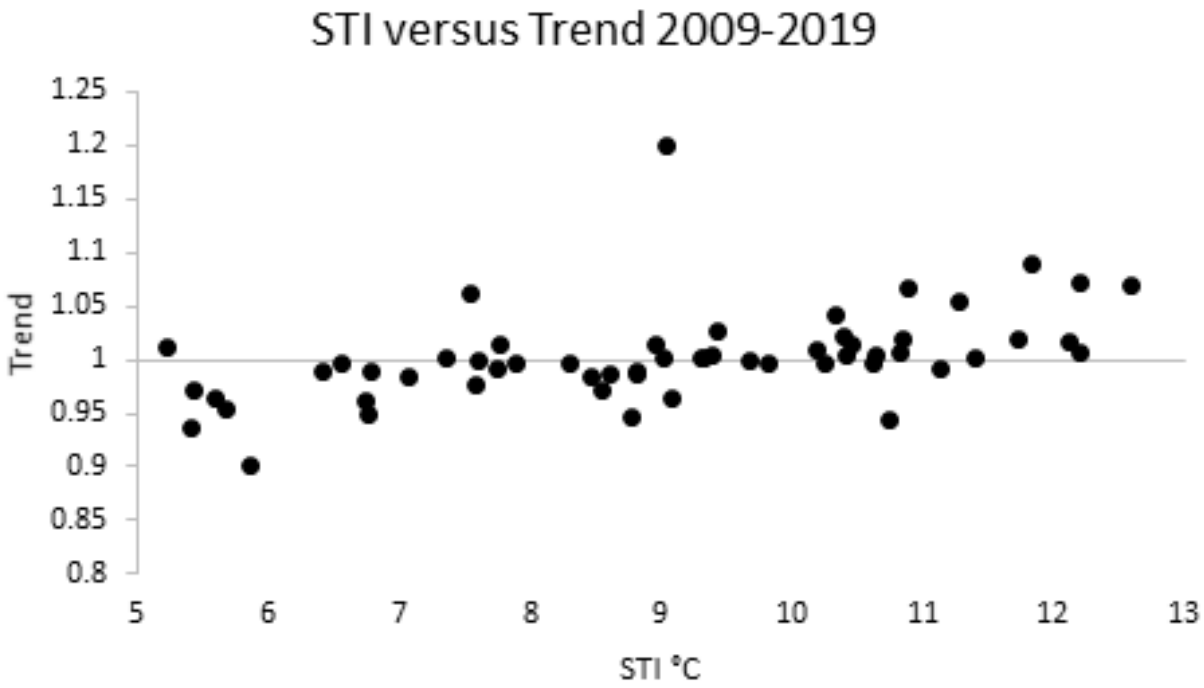

Figure 5. There is a positive relationship between the Species Temperature Index and its distribution trend over the last 10 years.

species with a low STI have a negative trend (with the exception of the very rare but stable *Somatochlora arctica*). There is a strong correlation between the STI and the log of the 10 year trend with an R^2 of 25%. This means that 25% of the variation in distribution trends among species is explained by their preferred temperature alone.

Figure 5. *Leucorrhinia caudalis*. Photo credit: Antoine van der Heijden.

Conclusion

The Dutch dragonfly fauna is very dynamic with winners and losers over the last 30 years. Unexpectedly, critical species such as *Leucorrhinia caudalis* (Fig. 5) come back while very common species suddenly decline. Overall we can see differences in trends of species from different habitats. The improved water quality in running waters and the recovery of the dragonfly species of this habitat is a clear, positive example. A major driver of changes in the dragonfly fauna is climate change and this will very likely continue to be so. This is most obvious through the increase of thermophilic species but likely also plays a role in the decline of species of moorlands that prefer lower temperatures. These impacts will not only be through changes in temperature itself but also increasing extremes, in particular droughts.

Thanks to the large numbers of citizen scientists that record dragonflies in the Netherlands, we can at least track these changes and aim conservation efforts where they are needed most.

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Fishing dragons in Colombia! A collecting daydreaming during COVID-19 times

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In the northwest Andes, there is a highly conserved rainforest within the National Natural Park Farallones de Cali, Colombia. Surprisingly, an incredible work of engineering appears in the middle of this extreme nature topography, the hydroelectric complex Anchicayá. This clean energy complex was built during the 1940s and 50s decades, and its construction took almost 20 years and a huge number of lives. Now, the Anchicayá river reservoirs produce 355 megawatts covering power for almost all the northwest of the country. This breathtaking place has a lot of primary forest and countless numbers of creeks, brooks, and cascades, surrounded by all kinds of fauna and flora, becoming one of the biodiversity hotspots of the Tropical Andes.

Figure 1. (A-B) Murals at Finca el Descanso, Doña Dora. (A) Spring Tanager (*Anisognathus sumptuous*). (B) Green Hermit (*Phaethornis guy*). (C) Our base camp at el Alto Anchicayá. (D) Employees' food court. Photo credits: Melissa Sanchez Herrera.

Figure 2. (A) Anchicayá Forest. (B) Bajo Anchicayá Forest. (C) Plaque to the memory of the fallen workers in a brave fight against nature to make this engineering work (the Anchicayá hydroelectric complex) a reality. (D) *Argia indicatrix* (Swamp Dancer). Photo credits: Melissa Sanchez Herrera.

This was the perfect scenario for our new research project with our beloved odes: "Fishing dragons: mitogenomes, barcodes and environmental DNA of odonates as a tool for the conservation assessment of freshwater systems in Colombia". Our aim is to identify all the odonate species living in the Anchicayá complex and develop a fast and accurate molecular tool to assess the conservation state of its freshwater systems using the genetic diversity of our beloved bugs. To do so, we have been collecting every two months since September of 2019 in this amazing scenario. So far, before the COVID-19 emergency started, we had completed three 5-day expeditions for the collection of adults, nymphs, and water environmental samples. We have collected a total of 108 adults, 102 nymphs and 45 environmental samples. Until now, we have a record of 35 species, the most common of which are: *Argia indicatrix* (Swap Dancer); *Libelulla herculea* (Hercules Skimmer), *Uracis imbuta* (Tropical Woodskimmer), *Erythrodiplax fusca* (Red-face Dragonlet) and *Cannaphila mortoni* (Morton's Skimmer). Some of our rare and low abundance taxa are: *Miocora aurea* (Coppery Cora), *Miocora peraltica*, *Mecistogaster modesta*, *Megaloprepus caerulatus*, *Argia mauffrayi* and *Archilestes chocoanus* among others. There are a few species we have only seen as larvae, *Perigomphus basicornis*, *Progomphus phyllochromus* and a *Neocordulia* (most likely *N. batesi*). Our preliminary data suggested there is a seasonality in the odonate community, so we do expect to be able to go back into our adventures within this amazing forest.

Figure 3. (A) *Erythrodiplax fusca* (Red-face Dragonlet). (B) *Libellula herculea* (Hercules Skimmer). (C) *Argia mauffrayi* male. (D) *Archilestes chocanus*. (E) *Perigomphus basicornis* larvae. (F) *Neocordulia* sp. larvae. (G) Polythorid larvae, possibly *Miocora*. Photo credits: Melissa Sanchez Herrera.

Here we briefly describe our itinerary for one of our 5-day field expeditions. We usually take a 45 min flight from Bogotá to the capital city of the Valle del Cauca department (i.e. state), Cali. Once we are in the Cali airport, which is not really inside the city (it is actually closer to another town named Palmira), our friend and driver Bladimir picks us up and takes us for a 30 minutes ride to our small hotel near a famous park in the city called El parque del Perro (yes, the Park of the DOG!). A place full of restaurants with a statue of a dog in the middle of it! This statue is to commemorate the relationship between us humans with our best friends, dogs. During that day we go to the groceries store to buy any other necessary food or equipment needed for the journey towards the Anchicayá complex. The next morning, usually around 7:00 AM, Bladimir picks us up and we start a 3 - 4 hour road trip heading northeast from the city, taking the road towards the sea. This road harbours a lot of mostly horrific history of our country, we pass through places where mass kidnapping events happened

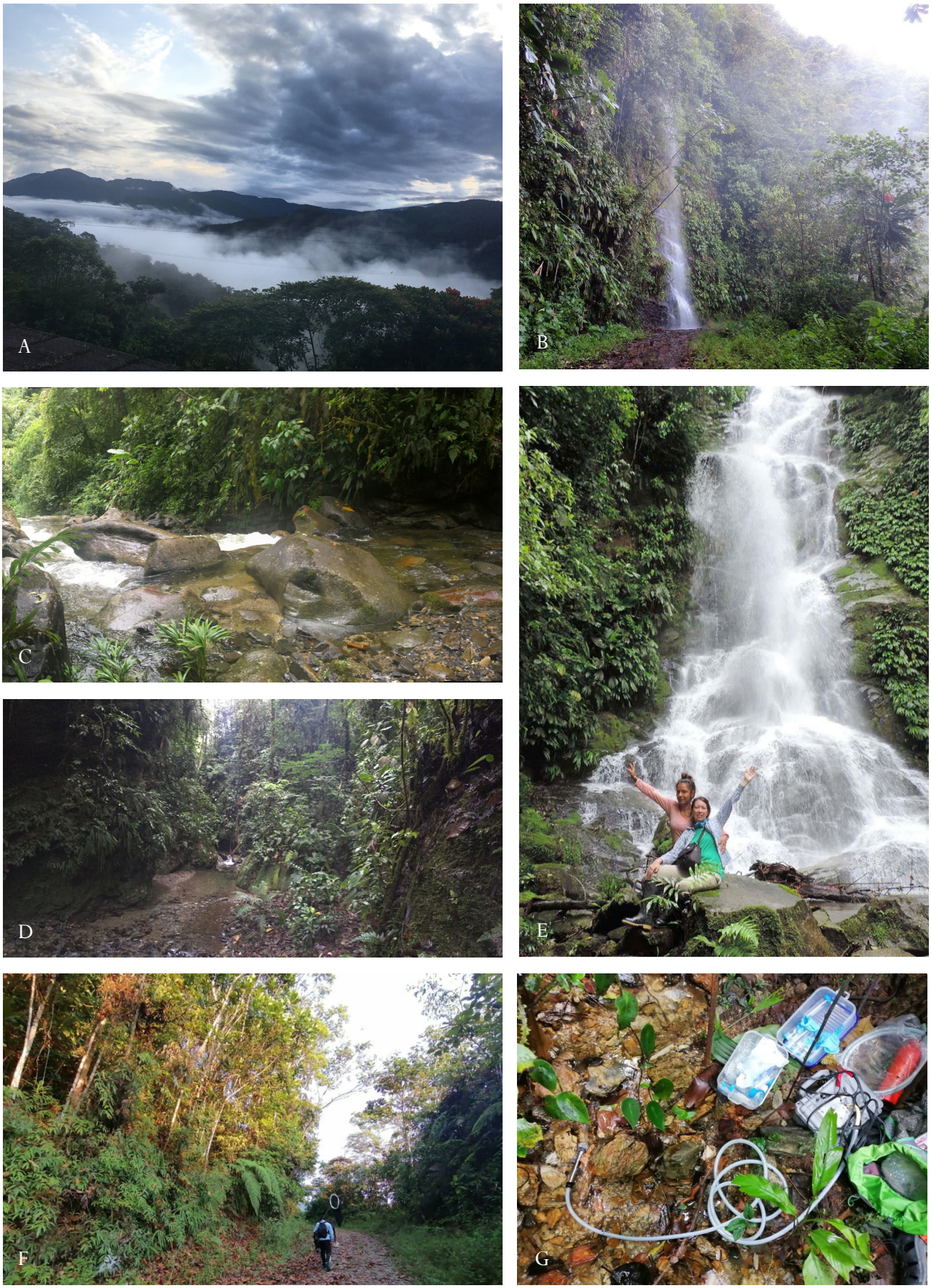

Figure 4. (A) Every morning view from our camp. (B) Waterfalls. (C) "La Riqueza". (D) "La Loca". (E) Waterfall, Vanessa Amaya and Melissa Sanchez. (F) Walking in the trails. (G) eDNA water sampling. Photo credits (A-D, F-G): Melissa Sanchez.

during the 1980s and 90s, times when the drug lords were controlling everything here. However, after confronting some of our near history, we arrive at a wonderful place to drink coffee, eat great empanada, and do some incredible bird watching: Finca el Descanso, Doña Dora (km55).

Dora Londoño[1] is a woman whose family was displaced by violence from her hometown and ended up building a paradise for birdwatchers. One of her sons is an artist and he has painted all the walls in her tiny but beautiful house with murals of all the bird species you can see around her farm. Every morning, she wakes up to feed fruit to the birds in her backyard and they come and stay for hours. This allows a lot of tourists to visit her farm in order to get a closer look at these birds. Then she starts making coffee and her famous empanadas to feed all these hungry visitors. She has an incredible sustainable business and is clearly promoting the conservation of this forest. After a few minutes of birdwatching, dragonfly conversations, coffee, empanadas and playing with the puppies, we continue our journey. After around an hour and half of uncovered road, we finally arrive at a double electric door across the river, where we are received by the security guards of the Alto Anchicayá reservoir.

These guards take our IDs and all the paperwork we have previously done to ensure our entrance to this complex. After making calls to make sure we can come in they let us go for a 20 minute drive all the way up to the camp where most of the hydroelectric workers are staying. The company running the hydroelectric complex is Celsia, and they kindly offer us as researchers a house where we can stay while we perform all our activities. Finally, we arrive at our designated house, and then go have our first lunch meal at the food court with all the employees. After a good and complete meal, if we are lucky with the weather we venture into a close trail near our house. At the end of this trail we find our first small creek called "La Loca" (The Crazy), not sure why the name. We usually stay there until 17:00 when the sun goes down around that time. Finally, we go for dinner and then head to look for frogs around the camp and just chill to wake up early next morning.

Over the next few days our schedule varies depending on the place that we are going to visit. We have two different localities besides "La Loca" within the forest where we are performing all our collecting activities. "La Riqueza" (i.e. "The Richness") which is around a 15-minute drive from our base camp and a 12km walk from the main road. The other trail that we visit is 12km of the main road towards the main entrance. Sometimes, we have lunch in the field overlooking the wonderful forest, sometimes we go to the employee's food court. Every evening we identify, preserve and photograph all our samples, and prepare all the equipment needed for the next day. Waking up every day in such a wonderful place is a great gift, we feel a connection with the grandeur of nature. We were hoping to work with primary schools this April to celebrate Earth Day, and teach them about the dragonflies and damselflies that live around them. We really cannot wait to go back, to feel the mist in the mountains, to hear all the birds and see all the bugs that this breathtaking place offers us. Watching all our pictures has been a great way to cope with the uncertainty during these COVID-19 days, and we hope that this story will help you as well.

Figure 5. (A) Anchicayá Team after a 4-hour hike in the woods, Juan Pablo Mongui, Vanessa Amaya and Melissa Sanchez Herrera. (B) We hope to be in these clouds soon! For now, just daydreaming in quarantine COVID -19! Photo credit: Melissa Sanchez Herrera.

1 If you want to know more about Dora Londoño please visit her facebook page: Link.

Name-bearing types and type catalogues of Odonata

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According to Article 61.1 of the International Code of Zoological Nomenclature 'Each nominal taxon in the family, genus or species groups has actually or potentially a name-bearing type. The fixation of the name-bearing type of a nominal taxon provides the objective standard of reference for the application of the name it bears' (International Commission on Zoological Nomenclature 1999). I will not further discuss the many subtleties around 'name-bearing types' that are explained in the Code, but the importance of type specimens is beyond doubt. They define the meaning of *Pantala flavescens* or any other name odonatologists use daily.

Type specimens connect nomenclature and taxonomy. Taxonomy deals with concepts: defining natural groups based on specimens examined (a species, genus, family etc.), ultimately resulting in a classification. The valid name of a natural group is the domain of nomenclature. Taxonomists first work out, based on taxon concepts, which names have to be considered. So, which types belong to the taxon distinguished. Name-bearing types of species are actual specimens. After studying descriptions, illustrations or the real specimens preserved in a collection, taxonomists can decide which names are relevant and available. Without going into details here, the oldest available name has priority and has to be used as the valid name of the taxon.

What are 'name-bearing types'? Nowadays, taxonomists typically designate just one specimen as the name-bearing type of a species (or subspecies). This is the holotype. However, it is allowed under the present Code to designate more than one specimen as name-bearing type: these specimens are all syntypes. Taxonomists until the 1950s did not often explicitly select one specimen as the type. Consequently, all specimens mentioned in the original description are syntypes. Taxonomists may select one of the specimens of the syntype series as the unique name-bearing type, which then is the lectotype. Lectotype designation under the present Code is restricted, and is not allowed as a curatorial action. The last category of name-bearing types are neotypes, which are designated if all type specimens have got lost and a name should be rigorously defined.

Apart from the name-bearing types, we also know paratypes and paralectotypes. The allotype, the first specimen of the opposite sex of a nominal taxon, is a special case of a paratype. Paratypes are the specimens assigned to a newly described taxon by the original author. They define the concept of the species. Paralectotypes are all previous syntypes of a name after the designation of a lectotype. Neither paratypes nor paralectotypes are name-bearing types.

Needless to say that name-bearing types, or primary types as they were previously called, are essential for communication in biology. They are usually kept in natural history museums. The International Commission on Zoological Nomenclature has stressed the value of type specimens in Article 72.10, '... They are to be held in trust for science by the persons responsible for their safe keeping'. This Article is followed by Recommendations 72D-F, dealing with labelling of specimens and the responsibility of institutes, including 'publish lists of name-bearing types in its possession or custody'. The availability of critical type catalogues with complete label data and preferably with illustrations of specimens and labels, is crucial for efficient taxonomic revisions.

I present here information on published catalogues of types of odonates. The focus of this paper is on more or less complete catalogues of institutions or of taxa described by one author. I am aware that many museums have made databases of their collections, including type specimens, available on internet. A good example is the collection of Linnaeus (linnean-online.org). I will not evaluate these in the present contribution.

Individual authorities or collectors

The first detailed catalogue of Odonata types was published by Calvert (1898), on the types of species described by Burmeister. This article enumerates all species described by Burmeister (1839) in *Handbuch der Entomologie*, p. 805-862. Calvert successfully recovered most of the types of Burmeister's species in the museum of the University of Halle (now: Martin-Luther University). He also found that part of the types were not preserved in Germany, but in the USA (Museum of Comparative Zoology, Harvard, Massachusetts – see below), and Austria (Natural History Museum, Vienna). Calvert gave the number of specimens, and the details of the labels, for each species in each collection.

Watson (1968) listed the name-bearing types of species described by Fraser from the Dobson collection and now preserved in the Australian National Insect Collection (ANIC), and Watson (1969) recorded the types and their depositories of species described by R.J. Tillyard. Although most of the types were deposited in the (then) British Museum (Natural History), some remained in Australia or New Zealand, where they are now part of the collections of ANIC or the New Zealand Department of Scientific and Industrial Research. For an

inventory of all Fraser types, see below.

European collections

Taxonomy as a science started in Europe, and most of the oldest types can be found in European collections. Probably the first detailed Odonata catalogue of a public collection was published by Weidner (1962, updated in 1977), as part of the catalogue of the collection of the Hamburg museum. This is a relatively small collection of Odonata types. Most following type catalogues were prepared by specialists in odonates. Kimmins (1966, 1968, 1969, 1970) prepared the catalogue of the British Museum (Natural History) (now: Natural History Museum, London). Particularly the first part, devoted to the types of species described by F.C. Fraser, must have been a *tour de force*. During arranging the types by Kimmins, many 'discrepancies' were detected, which could partly be corrected in consultation with Fraser. Kimmins described the conditions under which Fraser, who was an officer in the Indian Army Medical Service, had to work in India, to make us understand how these mistakes could occur. Kimmins (1966) includes discussion of 379 species-group taxa described by Fraser, and lectotypes were designated for 108 taxa. Designation of lectotypes purely for curatorial purposes is no longer allowed under the present edition of the Code, since Article 74.7.3. rules that a lectotype designation to be valid must 'contain an express statement of the taxonomic purpose of the designation'. This means in practice that lectotype designations are only allowed if, with present knowledge, the syntype series consists of more than one taxonomic taxon.

After this revision Kimmins prepared the catalogue, in three parts, of the remaining name-bearing types in the Natural History Museum. Kimmins set a high standard for type catalogues in Odonata. Apart from the species-group name with original genus and authority, a reference to the original publication, and the full label data, also the present taxonomic status was given.

During the 1970s two more catalogues were published. St. Quentin (1970) provides the data of types in the Natural History at Vienna (Austria), and Lieftinck (1971) those of the natural history museums of Leiden and Amsterdam (The Netherlands). Unfortunately, St. Quentin's publication contains many omissions and needs a revision. Lieftinck's catalogue follows the format of Kimmins, and is both complete and with only minor mistakes. However, Garrison & von Ellenrieder (2019) identified several types of species described by Hagen in the Museum of Comparative Zoology, which Lieftinck had presumed to be in Leiden, although the label data varied from the original publication. The specimens in MCZ are definitely the 'real types'. When I was responsible for the collection in Leiden in the 1990s, I decided to remove the name-bearing types from the general collection, and place each specimen in a separate carton box, making it easier to locate parts that were broken off. During this exercise, it appeared that several types could not be located. Fortunately, we have been able to find most of them elsewhere in the collection since, but some types are still missing. As with Kimmins, Lieftinck also designated lectotypes, but Lieftinck failed to label quite a few lectotypes. In most cases this could be solved based on locality and/or date, but the lectotypes in some longer, homogeneous series with the same locality and date were not distinguishable. Lieftinck's catalogue is out of date now; additions of species newly described species after 1971 by Lieftinck himself, but also Belle, Dijkstra, Dow, Hämäläinen, Kalkman, Kosterin, Müller, van Tol, Villanueva and some others are lacking. It should also be mentioned that the collections of the Zoological Museum Amsterdam and the Leiden Museum were merged and are now housed in Leiden. The collection in Leiden includes name-bearing types of at least 913 nominal taxa.

The type catalogue of Schwarz-Waubke et al. (2003) for the collection of the Biologiezentrum Linz includes mainly paratypes, and one holotype, of odonates. Hoess (2006) listed the Odonata types of the natural history museum of Basel.

Martin Schorr (personal communication) informed me that his efforts (International Dragonfly Fund) to have the type specimens of the Krüger collection (now in Warsaw, Poland) catalogued have not been successful yet. A preliminary list includes 120 name-bearing types of 41 nominal taxa; types of two nominal taxa are missing.

Schneider (2004) presented a report of the discovery of type specimens described by J.J. Kaup and F.M. Brauer, preserved in the Hessisches Landesmuseum Darmstadt (Germany). These specimens were sent from the Dutch East Indies by von Rosenberg to Kaup for his collection. Brauer, working in Vienna, published a series of papers formally describing these species, partly in collaboration with Kaup. Before Schneider's publication with details per specimen, it was presumed that types of these species were preserved in Vienna, or had become lost.

The types of 14 nominal taxa preserved in the Deutsches Entomologische Institut were catalogued by Petersen & Gaedike (1968).

Turiault (2016a, b, 2018) started to catalogue the types in the Museum für Naturkunde Berlin (Germany). Three parts have been published until now. Many of the type specimens are presented in outstanding colour photographs, and the text of the labels is offered verbatim, and partly in colour photographs as well. Turiault has also tried to locate other specimens from the type series in other collections. Most information of the Berlin collection is available on the website of the museum as well.

American collections

Garrison, von Ellenrieder & O'Brien (2003) published a thorough type catalogue of the University of Michigan Museum of Zoology, Ann Arbor. It is fortunate that the authors duly described their observations, such as previous type designations and preservation status of damaged specimens. Garrison & von Ellenrieder (2019) prepared an even more comprehensive catalogue of the types in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA (MCZ). This publication includes reports of many unexpected findings. MCZ holds the collection of Hermann August Hagen (1817-1893), who worked with Edmond de Selys Longchamps between 1841 and 1893. Hagen was born in Germany, worked for many years in Europe, but emigrated in 1870 to the USA to hold a position at MCZ for the rest of his life. Before he moved to the USA, he had acquired several important European collections, including those of Toussaint de Charpentier and Eduard Eversmann, and parts of the Selys and Burmeister collections. The whereabouts of these collections was largely unknown in Europe for many years, which is illustrated by the incorrect interpretation of some names after examination of the types. Fortunately, this only concerns nominal taxa now considered synonyms. Also for American odonatologists this work includes many novelties, such as the type specimens of Thomas Say, which turned up in the collection of Thaddeus Harris. Most of these specimens were poorly, or even not, labelled and only expert odonatologists were able to solve many of the problems related to this collection.

In South America, most countries do not have national collections, resulting in comparatively small institutional collections. As is well-known, the Brazilian Museu Nacional in Rio de Janeiro with presumably the largest collection of that continent, was lost during a devastating fire in 2018. Fortunately, Costa & de Araújo Mascarenhas (1998) published a type catalogue describing all relevant details of the types, including the paratypes, then available. I am not aware of photographs made at the time to document these specimens.

Inventories of Odonata types of two collections in Argentina were published by Muzon et al. (2007) for the Museo de la Plata (6 holotypes, 1 neotype), and von Ellenrieder (2009) for the Museo de Ciencias Naturales de Salta.

Other collections

The number of collections outside Europe and the USA is limited. Many of the types specimens of tropical species are preserved in European museums. For Asia, again only a few collections keep more than just a few type specimens. The collection of the Zoological Survey of India is of importance for types of part of the species described by Fraser, and various Indian authors since the 1950s. A welcome catalogue of the types of the National Insect Collection was published by Sheela et al. (2016), which includes many illustrations of the types as well.

Chen (2004) is an annotated catalogue of the Odonata types in the insect collection of the Institute of Zoology of the Chinese Academy of Sciences, Beijing. This collection includes the types formerly in Museum Heude (Shanghai), and many of the types of species described by H.F. Chao in the 1950s. Note that not all listed types are actual name-bearing types. From Museum Heude many types of species described by Navás are now in Beijing. Li et al. (2015) provided a similar catalogue of the Odonata in the Kunming Institute of Zoology of the Chinese Academy of Sciences in Yunnan.

The type collection of the Entomological Institute of the University of Hokkaido was catalogued by Asahina (1961). This collection includes many type specimens of Matsumura and Oguma. Label data are presented, but Asahina described that many specimens lack exact labelling. Lectotypes were designated among syntype series.

Further east, the Australian National Insect Collection houses many types of species from that continent. Details, also of other Australian species, can be found in Houston & Watson (1988), but the transcription of the labels is incomplete, and no illustrations are provided. Besides, many new species were described from Australia since.

An excellent catalogue of the type collection of the Natural History Museum of Zimbabwe (Bulawayo), the only large odonate collection on the African continent, was prepared by Dijkstra (2007a, b). This museum keeps 63% of the types of species and subspecies described by Elliot C.G. Pinhey. This catalogue in two parts discusses not only the types, but also provides the taxonomic status of the nominal taxa, and new illustrations of diagnostic characters.

Future catalogues

Many other museums worldwide keep name-bearing types of Odonata. Here I would like to mention larger collections of which I do not know type catalogues. The most important collection, with types of more than a thousand species, is that of Selys Longchamps, preserved in the Royal Belgian Institute of Natural Sciences at Brussels. Prepararation of this catalogue will be a task of years rather than months. Globally there are more. The following list is incomplete, but provides insight that we are still missing essential catalogues. In Belgium, we also have the Africa Museum (formerly Royal Museum for Central Africa). The Japanese National Museum of Nature and Science keeps most of the types of species described by Asahina. The collection of Erich Schmidt was entrusted to Asahina, and is also preserved in Tsukuba. The sorting of the specimens of this huge collection

is still continuing. Other collections with many Odonata types are those of the International Odonatological Research Institute, preserved in the Florida State Collection of Arthropods, the Academy of Natural Sciences (of Drexel University) (Philadelphia, USA), Cornell University (Ithaca, USA), National Museum of Natural History, Smithsonian Institution (Washington, DC, USA) and the Museum National d'Histoire Naturelle (Paris, France).

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Conflicting views on the status of *Orthetrum cancellatum kraepelini*

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Abstract
We present here different views on the taxon *Orthetrum cancellatum kraepelini* Ris, 1897. Friedrich Ris published the first species description in 1897 but in 1909 he changed its status to a subspecies. In December 1896, before the first description by Ris, Edmond de Selys Longchamps commissioned a watercolour of *O. kraepelini*. The accompanying text shows that Selys did not consider this taxon a species but a subspecies of *Orthetrum cancellatum*. Currently different views are held on its status. The distribution and various characteristics are listed to distinguish this subspecies from the nominal form of *O. cancellatum*. A thorough study of the specimens, the geographical distribution and possibly molecular differences in DNA is needed to determine the true status of *Orthetrum cancellatum kraepelini*.

Introduction

We became intrigued by *Orthetrum cancellatum kraepelini* following the discovery of an odonate watercolour (Figure 1) with '*Orth kraepelini*' written on the reverse side. It was discovered inside a box labelled 'Notes Cordulines' in the collection of the Belgian odonatologist Edmond de Selys Longchamps (1813–1900) on 19 April 2017. This watercolour is unique because it is stored separately from the rest of Selys' odonate watercolour collection in the Royal Belgian Institute for Natural Sciences (RBINS, Verspui & Wasscher, 2016, Verspui & Wasscher, 2017), and it is the only species of the Libellulidae that is depicted in Selys' watercolour collection.

Ris' view in 1897

Orthetrum kraepelini was described as a species by Friedrich Ris (1867- 1931) in 1897 from four males and five females. In this publication Ris pointed out that he visited the museum in Hamburg in July 1896 and became interested in some odonates from central Asia that were collected in Maralbachi at the River Kashgar-Darja (now Maralbexi in Xinjiang, China) in 1893. He viewed *Orthetrum kraepelini* as an intermediary species between *Orthetrum cancellatum* Linnaeus, 1758 in Europe and two *Orthetrum* species in Japan and China: *O. japonicum* (Uhler, 1858) and *O. internum* McLachlan, 1894. This new species was named after the director of the natural history museum in Hamburg, Karl Kraepelin (1848-1915).

Selys' view

The watercolour of '*Orth kraepelini*' (Figure 1) was commissioned by Selys. The signature GS indicates that the illustration was made by Guillaume Severin (1862-1938). He used the same style as for his other odonate watercolours that were all meant for Selys' never-published book *Histoires des insects odonates* concerning all Odonata species of the world. While all current superfamilies and the majority of the current families of Odonata

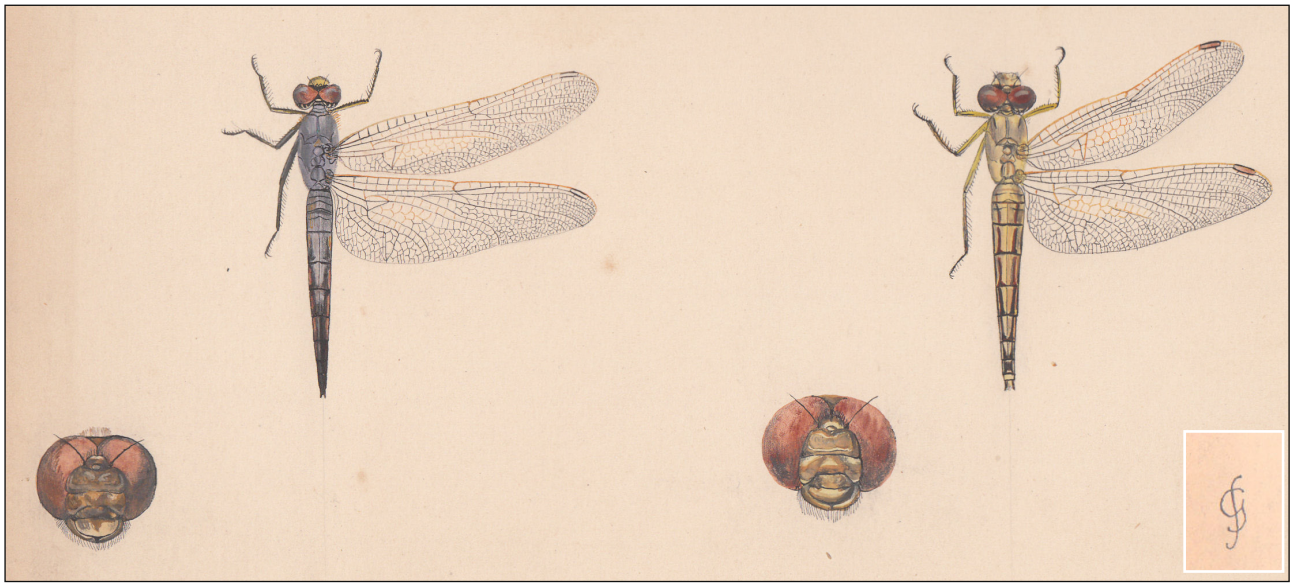

Figure 1. Watercolour of '*Orth. kraepeIini*', executed by Guillaume Severin, Selys collection (RBINS, 2020).

are represented in the folders of watercolours in Selys' collection in RBINS (Verspui & Wasscher, 2017), the species-rich family Libellulidae lacked representation until now.

We can date the watercolour because Selys wrote in his diary on 2 December 1896: 'Porté à M. Séverin, au musée, p. les dessiner, *Ur. nigra* ♂ ♀ et *Orth. kraepelini* appart. à M. le D. Ris' (Brought to Mr Severin in the museum to be painted *Urothemis nigra* male and female and *Orthetrum kraepelini* belonging to Dr. Ris). We checked the original handwritten diary (Figure 2A) that is part of the archives of the Library of the University of Liège. Selys' diary was transcribed and published by Caulier-Mathy & Haesenne-Peremans (2008).

Next to the watercolour, we found a text sheet in Selys' handwriting (Figure 2B) with the title '*Orthetrum Krapelini* [sic] Ris' that dated probably also from December 1896. Selys gave his opinion in the first sentence: 'Je crois que ce ne soit qu'une race locale pâle de cancellata' (I believe that this is only a local pale race of *cancellata*). He does not consider *Orthetrum kraepelini* a valid species but a race (comparable with the term subspecies nowadays) of *Orthetrum cancellatum*. This view differs from that of Ris at that moment who published the species description in 1897. In that publication Ris did thank Selys for his kind assistance. Selys noted also the four specimens of this race in his collection (Figure 2C) from the following localities: Bitlis (city and region in Turkey), Krasnowodsk (now named Türkmenbashi in Turkmenistan) and 'Tartoun'. We think this last locality is a misspelling of Tartoum (Arménie) where specimens of *Libellula cancellata* (now *O. cancellatum*) were collected by Théophile Deyrolle (Selys, 1887). Tartoum refers to Tortum in East Turkey (Jödicke, 1994).

Ris' view in 1909

Twelve years later Ris reconsidered and classified it as a geographic subspecies: *Orthetrum cancellatum kraepelini* (Ris, 1909). He mentioned another specimen of this subspecies collected in Astrabad, Persien (now Gorgan, Iran) and presented a key to distinguish between the subspecies *kraepelini* and subspecies *cancellatum*. Ris wrote that Selys' specimens from Bitlis (Turkey) and Krasnowodsk (now Türkmenbasi, Turkmenistan) in his opinion belonged to *Orthetrum cancellatum cancellatum* L.

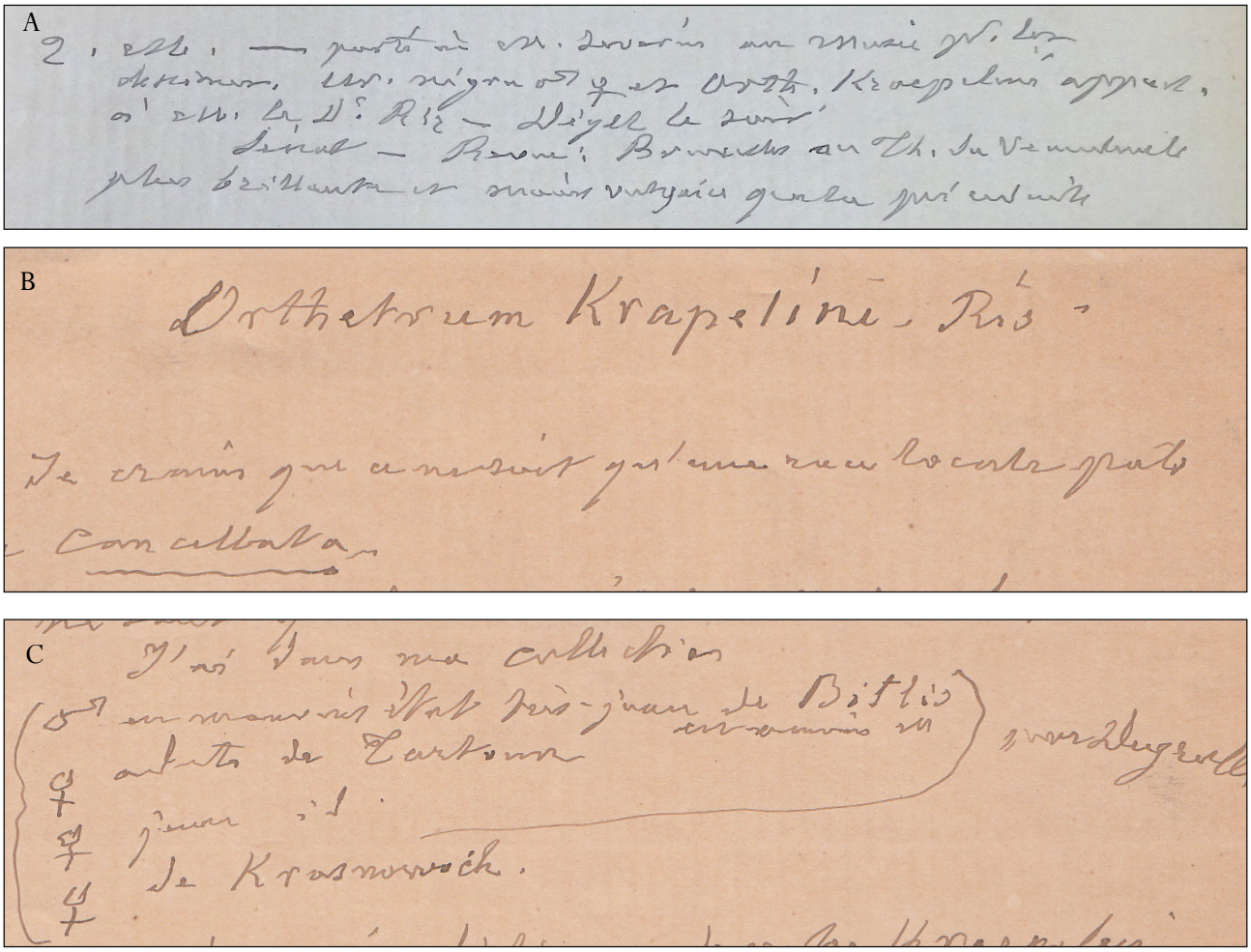

Figure 2. (A) Handwritten diary of Edmond de Selys Longchamps: entry, 2 December 1896 (archives of the Library of the University of Liège). (B-C) Text sheet in Selys' handwriting (Selys collection, RBINS). (B) Title *Orthetrum Krapelini* [sic] Ris and first sentence. (C) List of specimens and localities.

Different recent views

Although Ris and Selys in the end agreed and considered this taxon a subspecies, there have been many different views on the status of *Orthetrum cancellatum kraepelini* since: subspecies, uncertain taxon and not valid taxon.

It is a valid subspecies according to the 'Global Species Database of Odonata' (van Tol, 2020) and both Davies & Tobin (1985) and Tsuda (2000) agree. Borisov & Haritonov (2008) in their work on the dragonflies of Middle Asia also consider *kraepelini* a south-eastern subspecies of *Orthetrum cancellatum*. They give as range Northeast China (Maralbachi), Southeast Kazakhstan and Northeast Kazakhstan (Ust-Kamenogorsk). Grigoriev (1905) reported this subspecies from Lake Balkasj (Southeast Kazakhstan). The subspecies is also reported from different localities in Yunnan (China) (Fraser, 1924) but the studied material was according to Fraser badly macerated and could well be misidentified.

We consulted Matti Hämäläinen who considered the status of *Orthetrum cancellatum kraepelini* very uncertain [personal communication 19 April 2020].

In the opinion of Asmus Schröter *Orthetrum cancellatum* is a monotypic species that is very variable [personal communication, 8 April 2020]. Also Bridges (1994) considers it a synonym of *Orthetrum cancellatum*. The subspecies is not mentioned in works on the Odonata fauna in the expected range: Iran (Schneider & Ikemeyer, 2019, Schneider et al., 2018), Kyrgyzstan (Schröter, 2010), Kazakhstan (Chaplina et al., 2007) and China (Zhang, 2019).

The characteristics of subspecies *Orthetrum cancellatum kraepelini*

Ris (1897) in his first description of *Orthetrum kraepelini* mentioned that the pterostigma is small ('ptérostigma 2,5 [mm]') and brown reddish of colour ('petit, brun roussâtre'), the stature is a bit more slender than *O. cancellatum* ('un peu plus grêle') and the anterior lamina of the secondary genitalia is smaller and less deeply divided. The amount of yellow on the black legs is variable in males and very prominent on the legs in females. The wings have yellow veins apical from the triangle.

Ris (1897) noted one size 2.5 [mm] as the measurement of the size of the pterostigma in *O. kraepelini,* not distinguishing between males and females and mentioned in Ris (1909) 2 mm for males and 3 mm for females. The measures for *O. cancellatum* in Europe are in Schmidt (1927) for males 2.6-2.8 mm and for females 2.8-3.5 mm and in Robert (1958) males 2.3-2.8 mm and females 2.8-3.5 mm. So Ris' measurement in 1897 if for females is slightly smaller than in *O. cancellatum* and his measurement in 1909 for males is slightly smaller than in *O. cancellatum.*

A key is given in Ris (1909) to distinguish between the subspecies *kraepelini* and subspecies *cancellatum* using five characteristics (Table 1): colour of the pterostigma, colour of the venation, colour of the legs, stature and the shape and size of the anterior lamina of the secondary genitalia.

Borisov & Haritonov (2008) state that one of the important characteristics of *Orthetrum cancellatum kraepelini* is the yellow pterostigma in young individuals and this fits with Ris' description in 1909.

Comparison of illustrations with the characteristics

In search for recent visual records we studied the photos on the websites of Oleg Kosterin (2020) and of Observation International (2020). In the circa 100 photos from the described region, we found one recent documented observation of *Orthetrum cancellatum* specimens with some characteristics of *kraepelini* made by Robert Knoops in Kazakhstan (Figure 3). The female was found in the centre of Kapchagay near an artificial lake, situated 80 km north of the capital Almaty on June, 6, 2018.

We compared the characteristics of *Orthetrum cancellatum kraepelini* according to the key in Ris (1909) with those in the specimens illustrated in the watercolour of Selys' collection (Figure 1) and seen on the recent photo (Figure 3) (Table 1).

In the female specimen illustrated in the watercolour three characteristics can be determined and they conform with *kraepelini*. The identification of the male specimen on the watercolour is more difficult. The pterostigma can be white or maybe not filled in with paint. The yellow veins in the wing and the partly yellow legs in the male specimen however fit Ris' description. The secondary genitalia are not illustrated and cannot be assessed. On the photo the female has a yellowish pterostigma that fits the description of Ris (1909) and Borisov & Haritonov (2008). The veins in the wings and the front legs are blurry but seem dark in colour, not conforming with the characteristics of *kraepelini*. Stature is a characteristic that is difficult to determine in all three illustrated specimens. The specimens in the watercolour, especially the female can be identified as *Orthetrum cancellatum kraepelini* and the female on the photo has some characteristics from *Orthetrum cancellatum kraepelini.*

However a thorough study of the specimens and labels in the collections of Ris and Selys and the specimens from Kazakhstan together with the geographical distribution (Figure 4) and possibly molecular differences in DNA is needed to determine the true status of *Orthetrum cancellatum kraepelini*.

Figure 3. Photo of a female *Orthetrum cancellatum* with some characteristics of subspecies *O.c. kraepelini* made in Kapchagay (Kazakhstan), 6 June 2018. Photo credit: Robert Knoops.

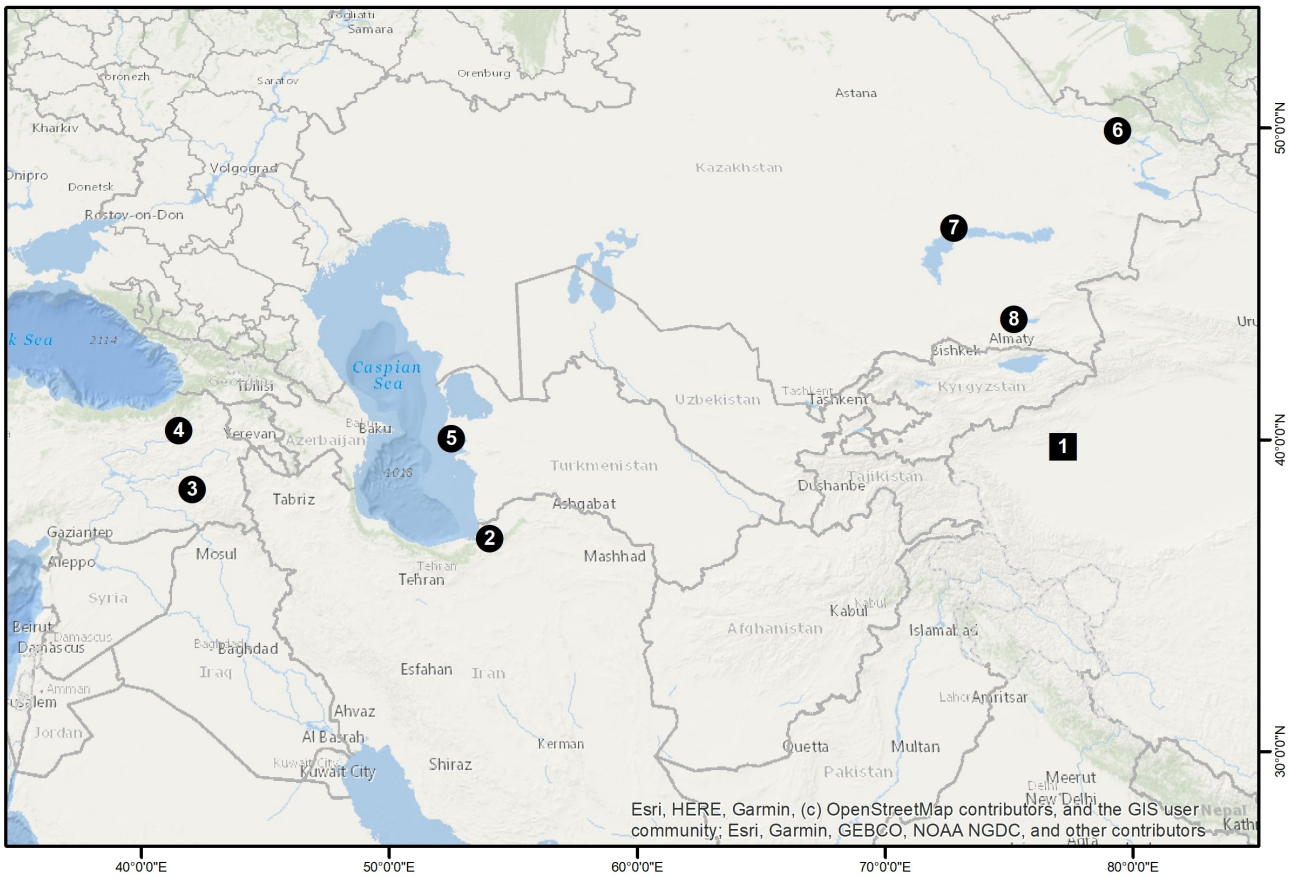

Figure 4. Localities of *Orthetrum cancellatum kraepelini*. 1 = type locality Maralbachi (Maralbexi, China) Ris (1897), 2 = Astrabad Persien (Gorgan, Iran) Ris (1909), 3 = Bitlis (Turkey) Selys (unpublished); according to Ris (1909) *O. c. cancellatum*, 4 = Tartoum (Tortum, Turkey) Selys (unpublished), 5 = Krasnowodsk (Türkmenbashi, Turkmenistan) Selys (unpublished); according to Ris (1909) O. c. cancellatum, 6 = Ust-Kamenogorsk (Öskemen, Kazakhstan), 7 = Lake Balkasj (Kazakhstan), 8 = Kapchagay (Kazakhstan).

Acknowledgements
We thank the staff of the Royal Belgian Institute of Natural Sciences (RBINS) for the access to the Selys' collection and the staff of the Library of the University of Liège for making the archives of Selys available. Asmus Schröter and Matti Hämäläinen are thanked for voicing their opinion. We are grateful to Robert Knoops for providing the recent photo and to Peter van Horssen for making Figure 4.

Table 1. Comparison of the characteristics of *Orthetrum cancellatum kraepelini* and *Orthetrum cancellatum cancellatum* in the key by Ris (1909) with those in the specimens illustrated in the watercolour '*Orth. Kraepelini*' (Selys collection, RBINS; Figure 1) and those in the recent photo of R. Knoops (Figure 3).

	Characteristics *O. cancellatum cancellatum* (Ris 1909)	**Characteristics *O. cancellatum kraepelini* (Ris 1909)**	**Watercolour male**	**Watercolour female**	**Photo female**
Colour of the Pterostigma	almost black	yellow reddish	whitish (or not painted at all)	light reddish	yellowish
Colour of the veins	only cross-veins and costa yellow	veins apical from the triangle yellow	veins apical from the triangle yellow	veins apical from the triangle yellow	veins dark
Colour of the legs	black with yellow exterior sides yellowish (female) black (male)	mainly yellow (female) femur and exterior sites tibia yellowish brown (male)	femur first leg pair yellowish the rest of the legs darker	mainly yellow	mainly dark
Secondary male genitalia	anterior lamina deeply divided	anterior lamina smaller and less deeply divided	-	-	-
Stature	robust	slender	-	-	-

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A quick tour of some libelluloid naughty bits

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Most readers of *Agrion* will certainly know something about the elaborate mechanisms of copulation employed by Odonata, but perhaps a quick review would be helpful here. The so-called secondary genitalia, including the intromittent organ, or penis, are held within a ventral genital pocket on the second abdominal segment; they have no homolog in any other organisms. In both major suborders, sperm is translocated from the primary genitalia, at the distal end of the abdomen, to the secondary genitalia, usually after a female has been seized by the head (in Anisoptera) or prothorax (in Zygoptera) by the male. The morphologies of the penis and of the hamules, which help to maintain the male's organs against the female copulatory pore, are usually species specific.

The penes of Anisoptera and Zygoptera are not strictly homologous between the suborders. In Zygoptera the sperm is deposited into a small flask-shaped structure, the sperm vesicle, at the posterior rim of the genital pocket. Immediately prior to intromission, sperm is extruded onto a separate sclerite, the genital ligula (GL), arising from the roof of the genital pocket. During copulation, muscles inserting on the GL and associated sclerites within the genital pocket contract to swing the GL downward and forward so that a channel on its posterior face rests just in front of the anterior opening of the seminal vesicle. Contraction of the latter extrudes sperm into the channel. Further antero-ventral movement of the GL thrusts it into the vagina of the female.

The Anisopteran penis is an extensive elaboration of an ancestral structure essentially like the seminal vesicle of Zygoptera. This is greatly elongated and jointed so that the extended distal portion can be folded within the genital pocket. It's structure and function is described in detail for a number of taxa by Pfau (1971, 2011). The basal segment, probably directly homologous to the zygopteran sperm vesicle, is visible just posterior to the rim of the pocket and extends forward within the pocket. The 2nd and succeeding segments are hidden inside when at rest. The 2nd segment is curved downward at about 90°, so that the joint between the 2nd and 3rd segments is barely within the pocket. At the distal end of the 2nd segment is a blunt, claw-like protrusion, and just at the base of segment 3 is a small aperture in a section of thick but flexible cuticle, through which sperm is transferred from the primary genitalia. This segment is directed backward beneath the 2nd and the distal part of the 1st and terminates, or perhaps better, culminates, in the 4th and final segment, which is the "business end" of the entire apparatus. It is where sperm emerges during insemination, from the

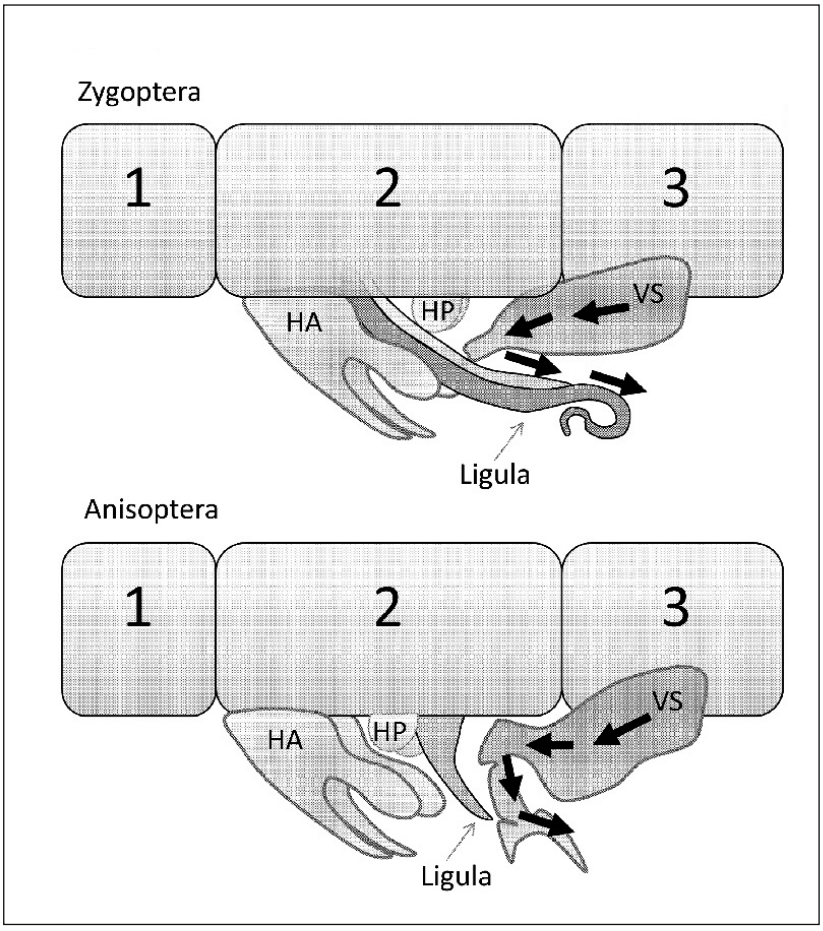

Figure 1. Schematic diagrams of penes of Zygoptera (above) and Anisoptera (below); GL – genital ligula, HA – anterior hamule, HP – posterior hamule, VL – vesica seminalis (seminal vesicle). In Zygoptera, anterior hamules are often nearly flat against the venter of segment 2. Posterior hamules may be much larger than shown (from Cordero-R. and Cordoba-G., 2010, with permission). The photographs that follow are generally inverted, i.e., ventral side up.

so-called "functional pore" (Pfau, 2011) and where various structures that function in sperm displacement often form what seems to be some strange modernist-rococo sculpture. Just before and during copulation, muscles in the 3rd abdominal segment contract to compress the basal segment of the penis. This in turn compresses spongy tissue within that and other other segments and causes the penis as a whole to expand and straighten. The process is assisted by the genital ligula which, in Anisoptera has only an indirect role in insemination. The GL is positioned much as in Zygoptera but its tip is modified not for sperm transfer but to fit over the distal protrusion of penis segment 2 and to assist the movement of the "new" penis

Ever since Jon Waage showed that male *Calopteryx maculata* remove sperm deposited by earlier partners from their current mate's bursa and spermatheca (Waage, 1979), the mechanisms and consequences of sperm competition in odonates have been studied intensely. Although the idea of sperm competition as an important influence on sexual, and thus evolutionary, success dates back at least to the work of Parker (1970), it is probably fair to say that Waage's paper thrust the phenomenon firmly into the view of entomologists and even, to some degree, of the general public. Much of the characteristic morphology of the odonate penis is adapted for removal of sperm of the female's previous mates as much as for transfer of sperm of the current male. In many Anisoptera, various lobes and extensions on the 4th penile segments are greatly distensible and, as the penis is inserted into the mate's vagina are inflated, often with the function of entering the female's bursa copulatrix and/or spermatheca and withdrawing any sperm already present.

The photographs below (Figs 2 - 11), mostly taken using SEM, are the remnants of a study, which never came to full fruition, of the evolution of the male genitalia of Libelluloidea. Although I ultimately abandoned the project, it did produce some interesting illustrations of the varied morphology involved in both insemination and sperm removal.

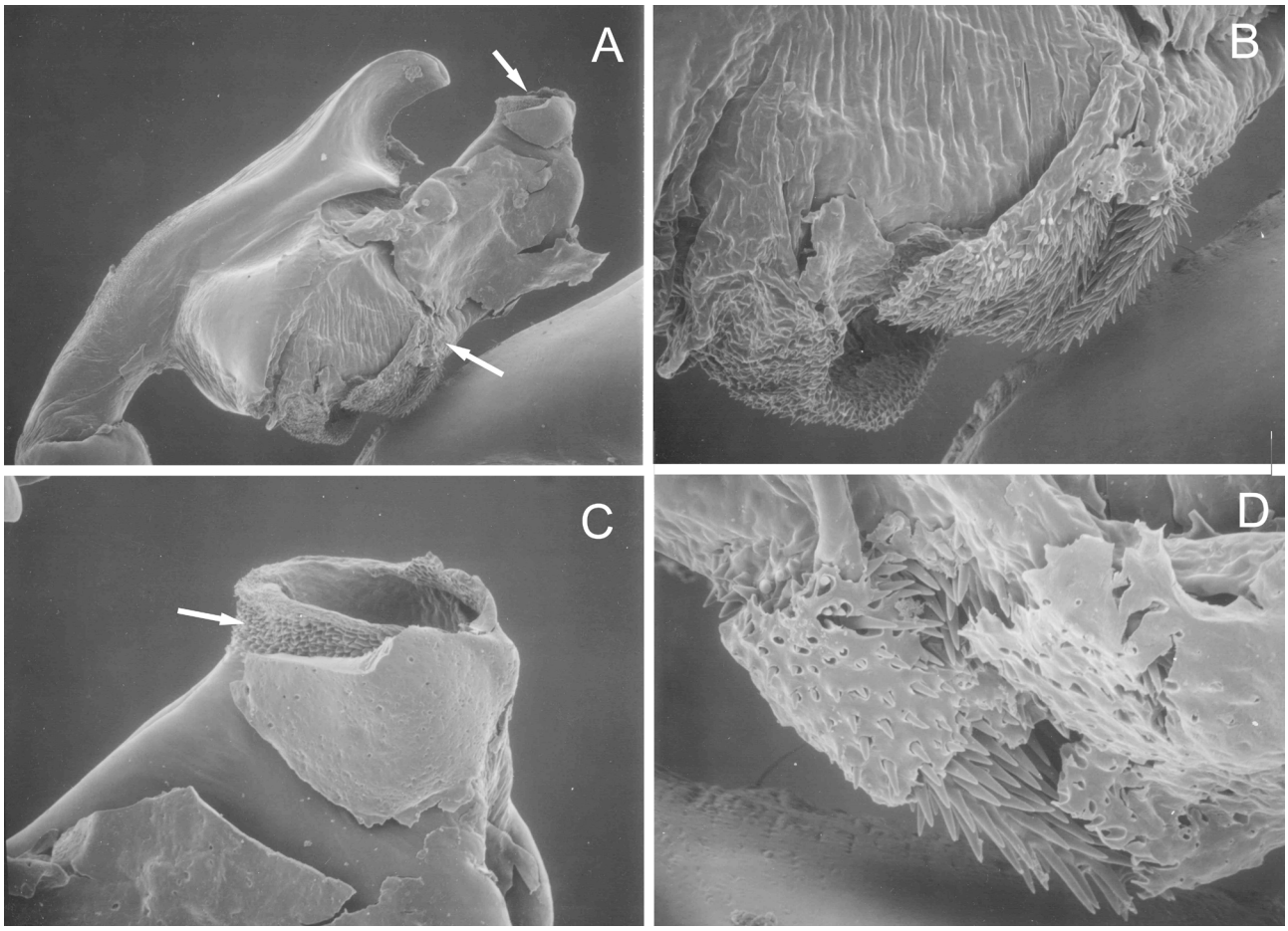

Figure 2. Fourth penis segment of *Cordulegaster sayi*, right lateral view. Arrows indicate features shown in B and C. (B) Portion of lateral flexible cuticle covered with spines that in turn are covered with dried semen from a rival male. (C) Pore at end of median lobe, partly covered with dried semen from a rival male; arrow indicates band of spinules surrounding pore. (D) As in B, from opposite side of penis.

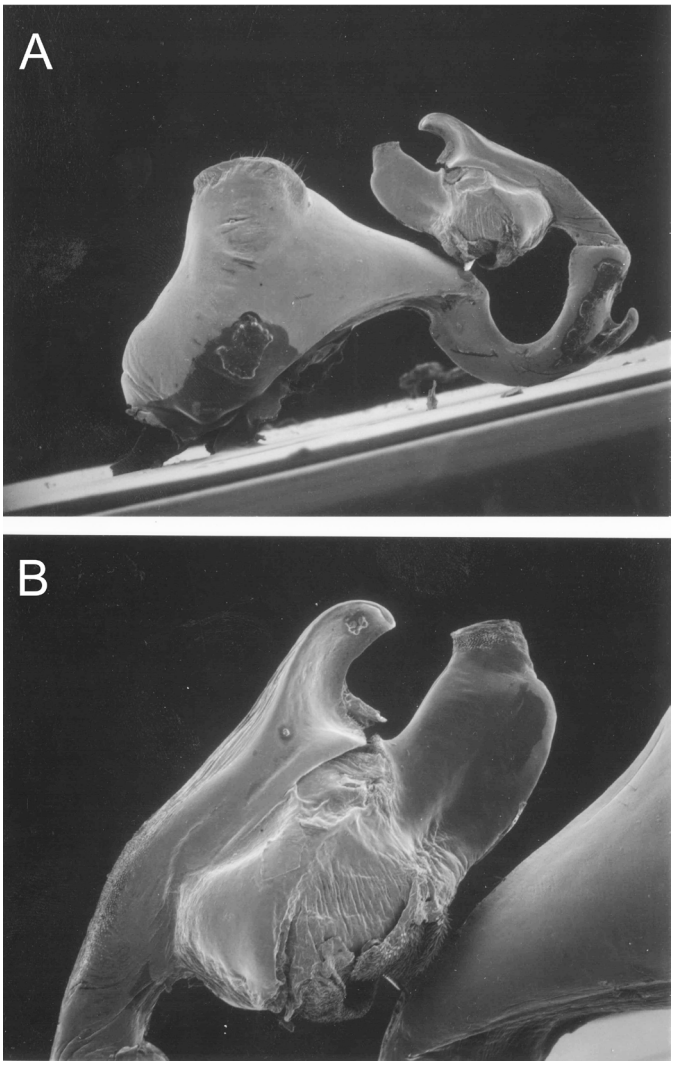

Figure 3. (A) Left lateral view of the same penis as in 2A with semen removed. (B) Right lateral view of fourth segment of *Cordulegaster sayi*.

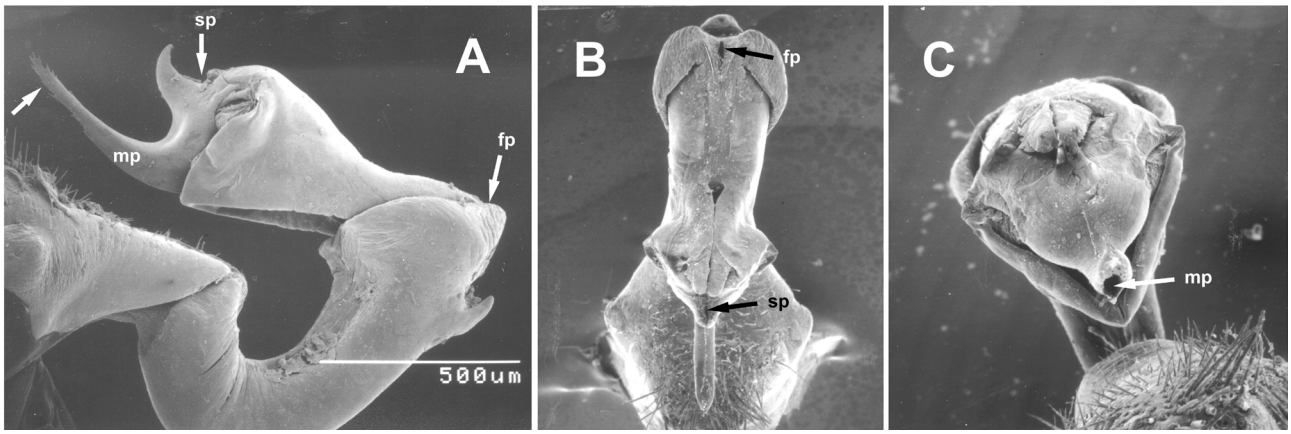

Figure 4. (A) Left lateral view of distal portion of penis of *Gomphomacromia paradoxa*. Arrows indicate the "fill pore" (fp) where sperm is introduced from the primary genitalia; the probable location of the sperm pore, where sperm is emitted during insemination; and the median process (mp), which may function in sperm removal. (B) Ventral view of penis of *G. paradoxa*. (C) Apical view of penis of *G. paradoxa*, showing pore at tip of median process. This may be involved in sperm removal (see below).

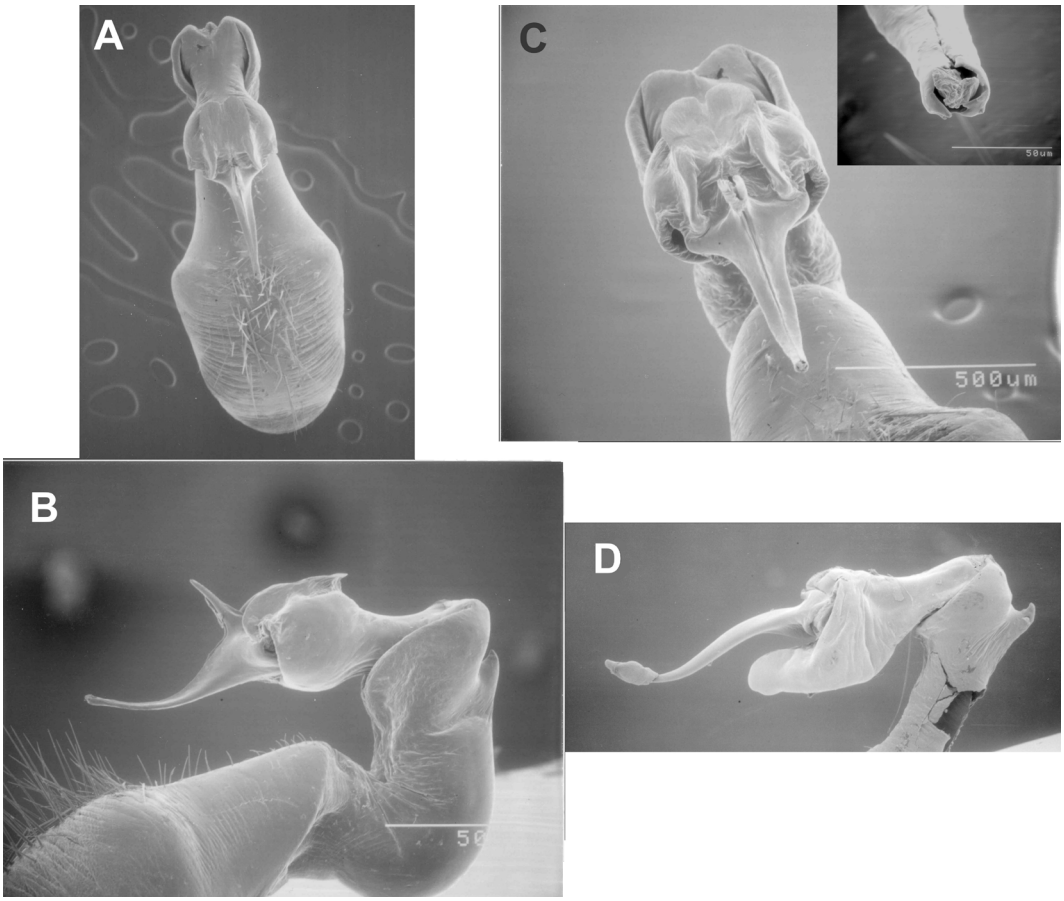

Figure 5. (A) Ventral view of penis of *Archaeophya magnifica*, an Australian species that may be related to *G. paradoxa* (although the penis is also similar to those of synthemistids (see below). The shapes below the penis are bubbles beneath the adhesive holding the specimen to the SEM stub. (B) Left lateral view of penis of *A. magnifica*. (C) Apical view of penis of *A. magnifica*; inset shows tip of median process with what is probably sperm from a rival male inside the pore at its tip, suggesting the possibility that sperm might be removed by a suction pump connected to the base of the mp. (D) Lateral view of distal portion of the synthemistid, *Synthemiopsis gomphomacromioides*, showing a small mass of probable semen at the end of the mp, again suggesting the possibility of suction removal.

Figure 6. (A) Right lateral view of distal portion of penis of *Synthemis eustalacta* (showing some remarkable external modifications). (B) Apical view of penis of *Synthemis eustalacta*; arrow indicates pore at the end of its flagellum, which is homologous to the median process of the preceding species.

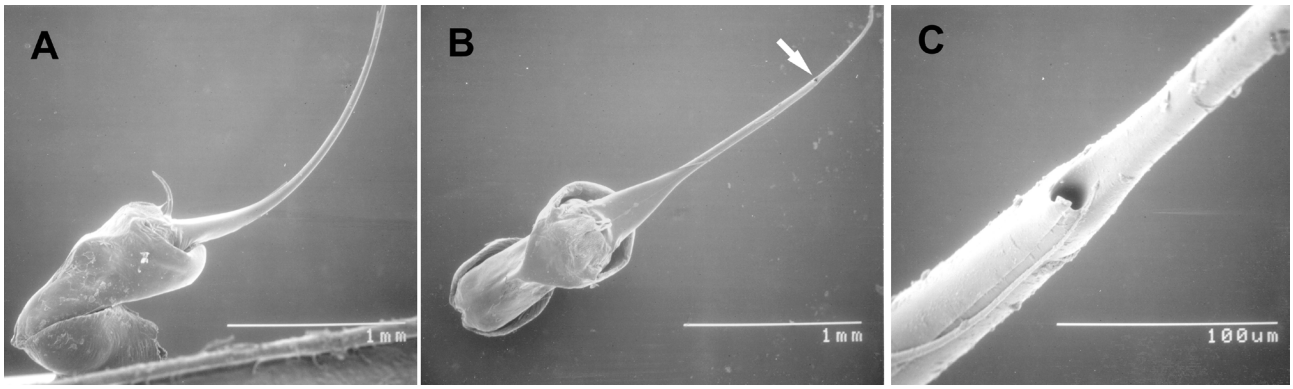

Figure 7. (A) Right lateral view of distal portion of the penis of an unidentified synthemistid, included here in part because it is the longest more-or-less rigid median process known to me. (B) Ventral view of distal portion of penis shown in A; arrow indicates preapical pore in medial process. (C) Close view of preapical pore shown in B.

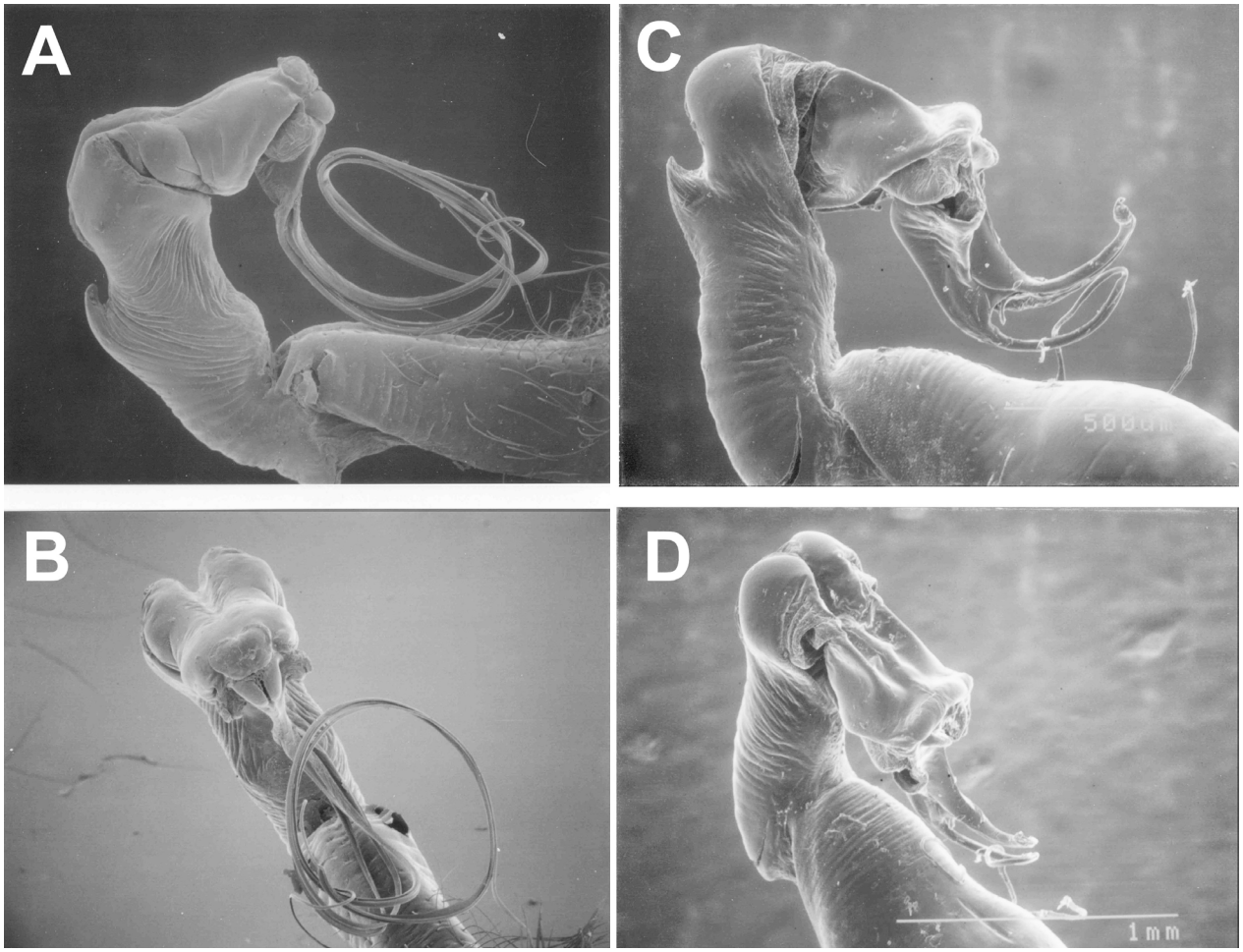

Figure 8. (A) Right lateral view of distal portion of the penis of *Epophthalmia elegans*. The median process forms three extremely long flagella. (B) Slightly oblique ventral view of penis of E. elegans. (C) Right lateral view of distal portion of penis of *Didymops transversa*. The median process consists of a flagellum of moderate length and a shorter, fleshy ventral extension. (D) Oblique ventral view of penis of *D. transversa*.

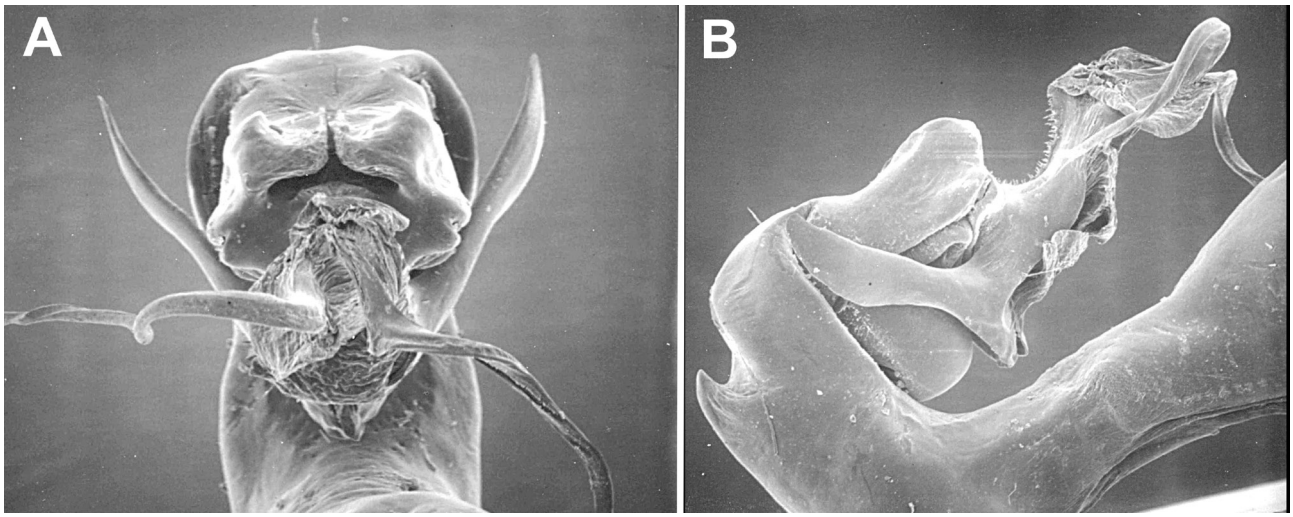

Figure 9. (A) Apical view of penis of *Lauromacromia dubitalis*. The paired flagella may extend into the female's spermathecae (although the morphology of the female genitalia is unstudied). (B) Right lateral view of distal portion of penis of *L. dubitalis*. Small spines along the ventral and dorsal edges of the median process may be used to remove sperm from the female's reproductive tract. The function of the wing-like, sclerotized projections is unknown.

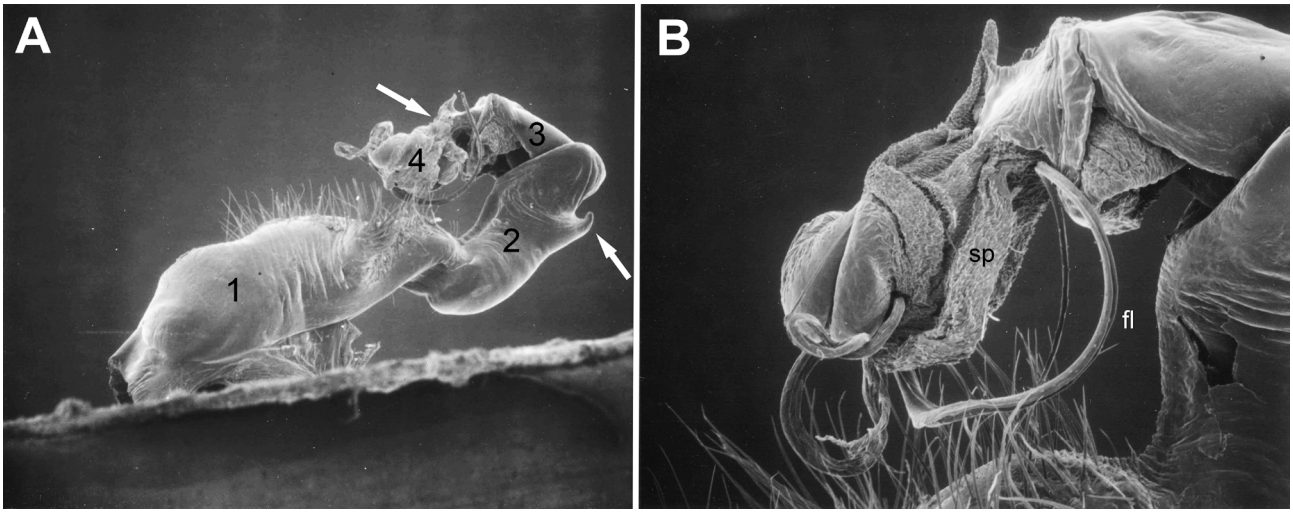

Figure 10. (A) Left lateral view of penis of *Cordulia shurtleffii*. The penile segments are numbered. Arrows indicate the protrusion on segment 2 that is engaged by the genital ligula (not shown) and the approximate location of the functional pore, where sperm is ejected into the female reproductive tract. (B) Closer view of segment 4 of the penis of *C. shurtleffii*. Note the flagella (fl), which may be used to extend into the spermathecae of a female to remove rival sperm, and the flexible (inflatable) cuticle covered with tiny spies (sp) that probably entangle and remove sperm in the female's bursa copulatrix.

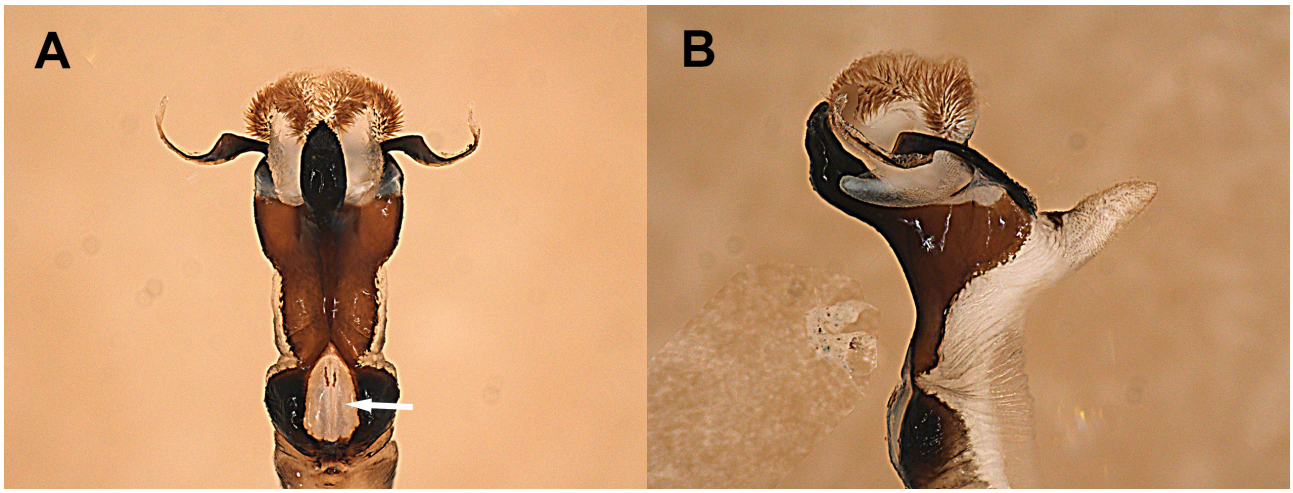

Figure 11. (A) Light micrograph of ventral view of the fully inflated terminal segments of *Libellula incesta*; arrow indicates position of the "fill pore". (B) Right lateral view of terminal segments of *L. incesta*.

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Marine dragonfly under threat at Lantau, Hong Kong (Odonata: *Orthetrum poecilops*)

Keith D.P. Wilson [kdpwilson@gmail.com]

During the preparation of this special issue of *Agrion* I was informed by Elaine Yuen, Assistant Education & Conservation Manager, Green Power, Hong Kong that her organisation had discovered breeding populations of Mangrove Skimmer (*Orthetrum poecilops*) at Tung Chung, Lantau Hong Kong, which is town adjacent to the Hong Kong International Airport. Furthermore, I was informed that these newly found populations were threatened by proposed developments at west Tung Chung. Given *O. poecilops'* unusual niche habitat requirements, its rare global status, its IUCN Red List status as Vulnerable (Wilson 2009), the current developmental threats at its breeding site next to Hong Kong's International Airport and my previous connections with the discovery of *O. poecilops* in Hong Kong and my historical association with the new airport project at Tung Chung, I thought it would make an interesting article for *Agrion*.

Background

On 7th January 1991 I travelled to Hong Kong to take up a three-year position as a Fisheries Officer in the Agriculture and Fisheries Department of the Hong Kong Government. Little did I know when I arrived at Kai Tak Airport for the first time that Hong Kong would be my young family's home for the next 13 years; until my two daughters reached tertiary education stage and we relocated back to UK. After a short stint at the Au Tau Fisheries Office, situated at a freshwater fish farming research station near Yuen Long in the New Territories, I was transferred to the Marine Fish Culture Division. One of my first tasks as a Fisheries Officer, with responsibilities for the management and regulation of the marine fish culture industry in Hong Kong waters, was the decommissioning of the Tung Chung marine Fish Culture Zone (FCZ) located on the north side of Lantau Island where the new Hong Kong International Airport was due to be constructed (see Figure 1). It was my job to help devise a compensation package acceptable to both Government and all the mariculturists who had licensed farms operating within the Tung Chung FCZ. Before a settlement agreeable to all parties was struck I was involved in a fair bit of on-site consultation with the mariculturists at the FCZ located just offshore from the small village

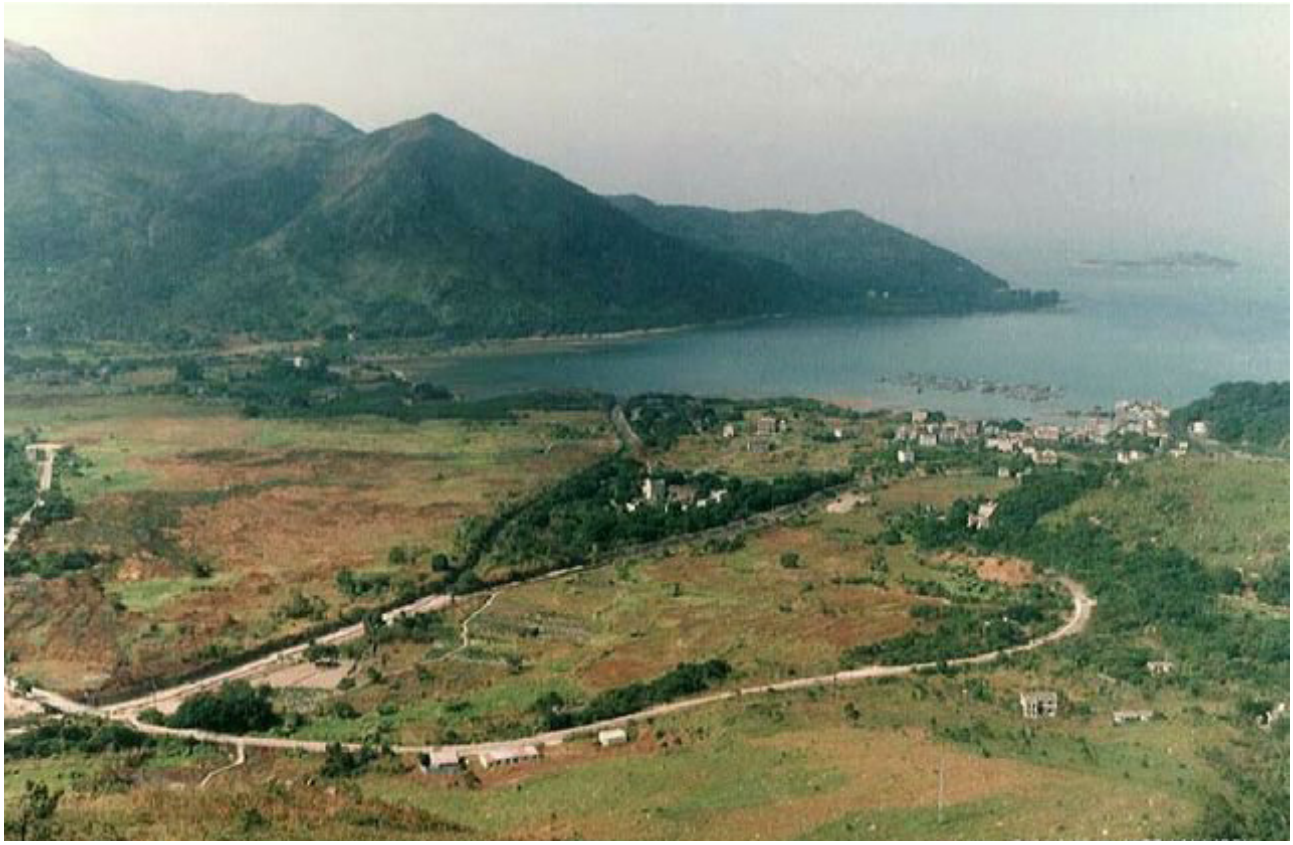

Figure 1. View from lower slopes of Sunset Peak over Tung Chung and its offshore marine fish culture zone in Tung Chung bay, 23 November, 1991. The photo was taken just prior to the decommissioning of the fish culture zone to make way for the construction of the Hong Kong International Airport. Photo credit: Gakei [Link].

of Tung Chung. I found the undeveloped ancient traditional fishing village of Tung Chung and the island of Lantau, which is larger than Hong Kong island, enchanting. The inhabitants of Lantau's two ancient fishing villages at Tung Chung and Tai O clearly enjoyed their relaxed lifestyle in idyllic rural settings surrounded by an extremely rich natural community. The village had a long history dating back at least to the Song Dynasty (960-1279 AD). I had ominous feelings about the immense programme of development that was about to radically change this undeveloped island located at the edge of the Pearl Estuary and the open South China Sea.

As soon as the compensation package was approved by the Hong Kong Legislative Council the Tung Chung FCZ was decommissioned and then reclamation works began in earnest in 1992 to create the new airport, which was then known as Chek Lap Kok Airport (now of course known as Hong Kong International Airport). The curious original airport name perhaps meaning 'Red Bream Point', referring to the name given for the small island located in Tung Chung bay, now largely flattened and transformed into the new airport platform. The old name may be a fisherman's reference to the local Red Seabream (*Pagrus major*), which has become a favoured fish in the Chinese seafood restaurant trade and is reared in Hong Kong FCZs from fry collected from spawning grounds in sheltered bays in Hong Kong during the late winter months. I hasten to add there are several other possible explanations for the name: *Chek Lap*. The ambitious and spectacular Norman Foster designed new airport was finally opened in July 1998. During the airport's construction the ancient Tung Chung village and surrounding area was also transformed into a new, mainly residential, town supporting 20,000 people (Figure 2). The first phase of development was completed in 1994 (20,000 people) and the second phase for 67,000 people is currently under construction. The Hong Kong SAR Government is implementing a planned development programme for Tung Chung in four phases with a predicted ultimate target population of ca. 250,000 people.

Two natural and precipitous watercourses cascade down the steep mountainous slopes of Sunset Peak (869 m) and Lantau Peak (934 m) to discharge in Tung Chung's muddy estuary lined with patches of *Kandelia* mangroves. During the period 2015 to 2019 the non-governmental environmental charitable group Green Power carried out annual dragonfly surveys at Lantau Island streams and wetlands and recorded *Orthetrum poecilops* at the mouth of the Tung Chung estuary at two small streams not connected to the two main streams; one draining the hills and marsh areas to the west of Tung Chung bay and the second draining Won Liu Tun hills immediately to the south of Tung Chung.

Figure 2. Tung Chung and Hong Kong International Airport viewed from Lantau Peak, 12 February 2006. Photo credit: Thorsten at wts wikivoyage [Wikimedia Commons].

Distribution of *Orthetrum poecilops* Ris, 1919

I first became aware of the presence of *O. poecilops* in Hong Kong in April 1994 when I observed mature males and collected a recently emerged teneral male next to mangroves (*Kandelia obovata*) at Nam Chung, in a remote area of the New Territories in northeast Hong Kong. The location of the teneral male was exactly on the boundary between *Phragmites* reed and *Kandelia* mangrove. The dragonfly and its habitat were intriguing so I revisited the site later in the season in August 1994 hoping to see if I could find any mature males. Indeed, there were several males holding territory at exactly the same location on 21 August 1994. I paid close attention to the unusual breeding habitat requirement at Nam Chung where a freshwater stream from a reedbed cascaded into a tidal mangrove (Wilson, 1995). I revisited the site in June 1995 and July 1996 and always found *O. poecilops* present in small numbers with males holding their territories by perching on mangroves at the breeding site and sallying off to chase away competing males. In September 2000 I found another breeding site at Hoi Pui Leng, not far from Nam Chung, in another small mountain stream draining through a small marsh into a muddy mangrove system at Starling Inlet. There I observed and photographed several adults and a coupled pair (Figure 3).

I wrote an article (Wilson 2001 Link) in a Hong Kong University newsletter known as *Porcupine!*, which was dedicated to informing on matters related to biodiversity and conservation, about the unusual dragonfly *O. poecilops.* I won't repeat the contents of that paper here but suffice to say I covered the biology of salt tolerant dragonflies, a meeting with Juzo Sawano[1] for a Japanese film documentary on *O. poecilops* and provided details of all global records in China, known at that time. *O. peocilops* is known from Japan (1 site), type-loc: Guangdong (1 site), Foochow, Fujian (Asahina, 1970: 1 site), Hainan (Zhang, 2019) and Hong Kong.

Hitherto, *O. poecilops* has been recorded in small populations in Hong Kong from mostly isolated rural coastal sites at eight locations in east and northeast Hong Kong, namely: (i) Nam Chung & Hoi Pui Leng, Yin Tso Ha (Starling Inlet), (ii) Yung Shue Au, (iii) Lai Chi Wo, (iv) Wong Chuk Kok Hoi (Double Island), (v) Shuen Wan, (vi) Yung Shue O, (vii) So Lo Pun (Wilson 1995, 1997, 2001, 2003, 2004, 2009; Saito & Ogata 1995; Tam 2011) and (viii) Fung Hang (Starling Inlet) (Reels 2019). The discoveries at Tung Chung (Lantau) by Green Power raises the number of Hong Kong site localities to nine clearly showing that Hong Kong is the most important location for this species currently known.

Figure 3. (A-C). *Orthetrum poecilops*, Hoi Pui Leng, Starling Inlet, northeast New Territories, Hong Kong, 3 September 2000. (A) Coupled pair in 'wheel'. (B) Female. (C) Young male.

1 Juzo Sawano rediscovered *Orthetrum poecilops miyajimaense* Yûki & Doi, 1938 at its original and only known site in Japan at Itsukushime, Miyajima, Hiroshima in 1957 - see Agrion 23[2]:54). Furthermore Juzo Sawano also discovered the larvae for the first time [Sawano, 1966].

Ecology

Orthetrum poecilops can be found at locations just above and below the tidal limit where small freshwater streams enter muddy estuaries or coastal inlets. The breeding sites are typically located where freshwater streams approach the maximum tidal limit, i.e. the Mean High Water Spring (MHWS) mark. Such locations are usually characterised by the presence of mangrove (*Kandelia obovata*) and reed (*Phragmites australis*). During the breeding season, males can be found holding territories by perching on *Kandelia* mangrove vegetation just below the MHWS where they will chase off competing males and pair with females. I do not know if *O. poecilops* larvae can survive in saline mud areas that are not flushed with freshwater. I'm inclined to doubt that possibility, but I do not know for sure. From my perusal of the literature it seems apparent that *Orthetrum poecilops* is the only dragonfly larvae in the Old World that can tolerate fully saline immersion for short periods during high tide. It's my impression that its habitat in streams below the MHWS needs to be flushed by freshwater stream input during the mid and low tide periods. I once tried to encourage Hong Kong University to study the larval requirements of *O. poecilops,* as it would make a fascinating study, but alas the University did not follow-up. Adults have been found at mangroves at short distances away from freshwater streams but this is not surprising. It does not mean that larvae can survive away from stream inputs.

The flora at some sites upstream of the *O. poecilops* breeding areas are typical of freshwater coastal streams and marsh systems and they support entirely freshwater species such as *Orthetrum luzonicum*. The latter species appears to outcompete *O. poecilops* in freshwater marshy locations above the tidal limit, where *O. poecilops* is absent. Since *O. luzonicum* larvae are presumably not tolerant of periodic salt immersion it is not found below the MHWS level.

The larvae (Figure 4) and larval habitat have been described at Miyajima, Hiroshima, Japan by Sawano (1966), Ishida (1969) and Ishida et al. (1988). The information given states that the general habitat is a coastal marshy area next to mountains where the larvae live in groundwater-fed ponds and marshes with odorous sludge substrates supporting 'Abragaya' (*Scirpus wichurae*) and reeds that may be invaded by seawater during high tide. The larvae can be found hidden in soft mud, under rotting leaves and amongst the roots of flooded plants.

Development proposals at Tung Chung west

To date most of the development that has taken place on Lantau at Tung Chung has been east of the original fishing village in Tung Chung Bay and northeast of Tung Chung bay (see Figure 5A). But now the Hong Kong SAR Government has just granted approval on 8 April 2020 to extend the Mass Transit Railway (MTR) from Tung Chung to Tung Chung West; the station to be built mostly underground west of the Yat Tung Estate (see Figures 5B & 6A). The MTR extension is part of a large development programme including an expanded Tung Chung West that is expected to support an additional population of 126,000 starting from as early as 2024. The original EIA studies found important sea-grass communities (*Zostera japonica, Halophila minor* and *Halophila ovalis*) in Tung Chung bay, some uncommon marine and freshwater fishes (*Anguilla marmorata, Syngnathus schlegeli, Plecoglossus altivelis* and *Hippocampus kuda*) and two species of horseshoe crab (T*achypleus tridentatus* and *Carcinoscorpius rotundicauda*) but the contractors failed to find any populations of *Orthetrum poecilops.*

Green Power have been writing regularly to the Hong Kong SAR Government to alert them to the findings of their dragonfly surveys on Lantau and to ensure the breeding sites at Tung Chung West of this rare and Vulnerable dragonfly are protected and considered in future planning and development proposals. Green Power have objected strongly to any development proposals that may harm the mangrove areas at Tung Chung West, one of which comprises a public transport terminus that impinges on a mangrove area.

The Hong Kong SAR Government has agreed to create a River Nature Park to protect the eastern arm of the Tung Chung River but this proposal omits the mangrove and reed areas and the western branch of the Tung Chung stream. A coalition of green groups including Green Power, WWF-Hong Kong, Hong Kong Bird Watching Society, The Conservancy Association, Eco-Education & Resources Centre, Designing Hong Kong and the Lantau Buffalo Association have jointly written to the various planning authorities to request that the government extends its Tung Chung River Nature Park so that it covers both the eastern and western sections of the river and the estuary (Green Power et al. 2016) - see Figure 6B. Such a proposal would certainly

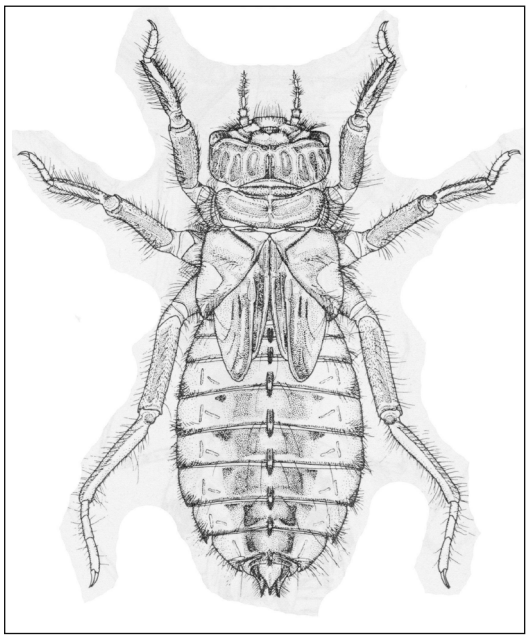

Figure 4. *Orthetrum poecilops* larvae Miyajima, Hiroshima, Japan, from Ishida et al. (1988).

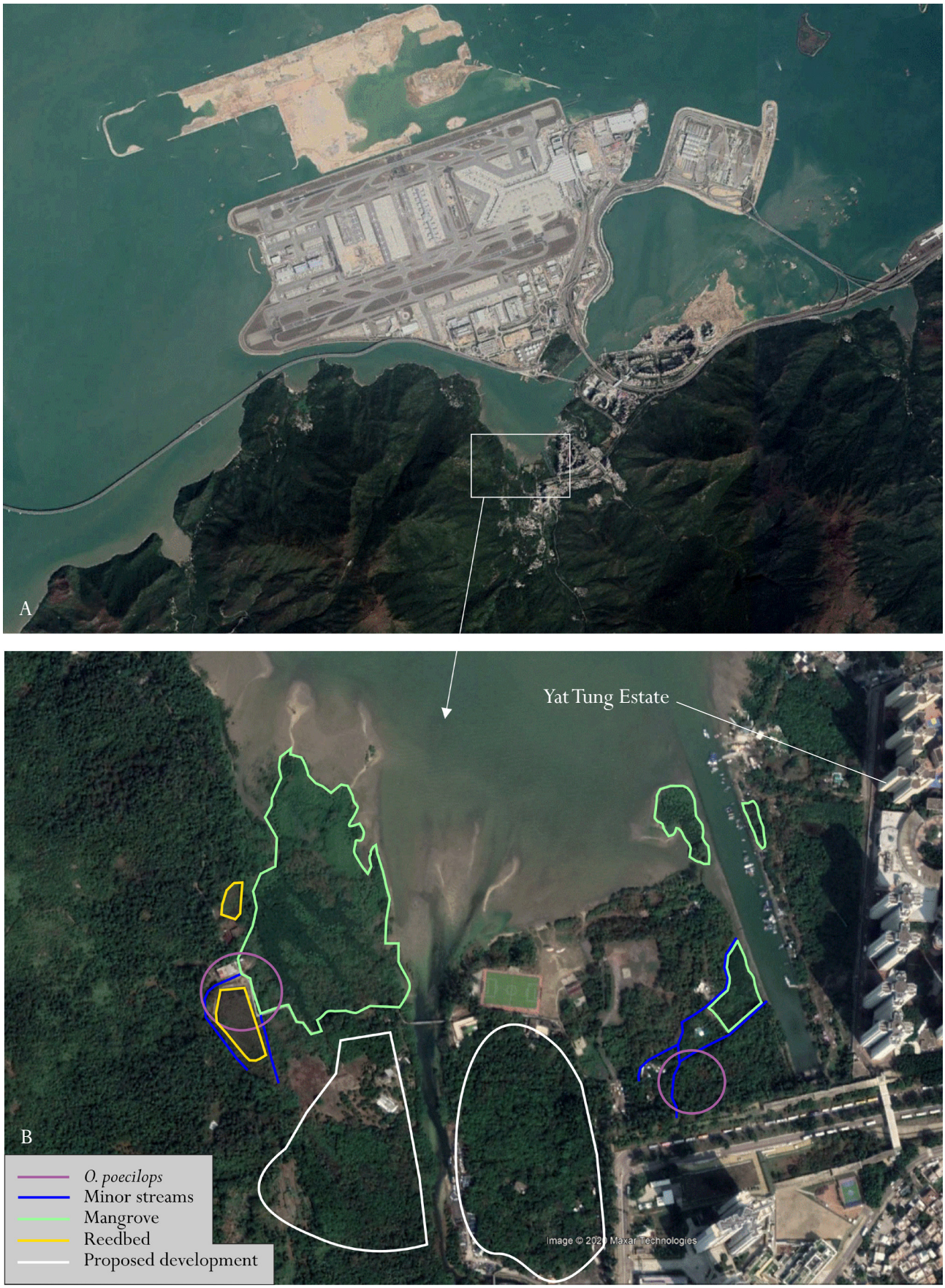

Figure 5. Google Earth satellite images of Tung Chung, north Lantau, Hong Kong. (A) Tung Chung and Hong Kong International Airport. (B) Image expansion of the white rectangle in A showing Tung Chung West, the original fishing village location of Tung Chung, with location of *O. poecilops* records, mangrove and reed habitats and proposed development areas.

help to protect the breeding sites of one of Hong Kong's most unusual dragonflies.

I wish Hong Kong's green groups every success in achieving their conservation goals at Tung Chung. I'm sure many of the hundreds and thousands of future residents at Tung Chung will be grateful if the Mangrove Skimmer continues to skim mangroves at Tung Chung. It's certainly unusual

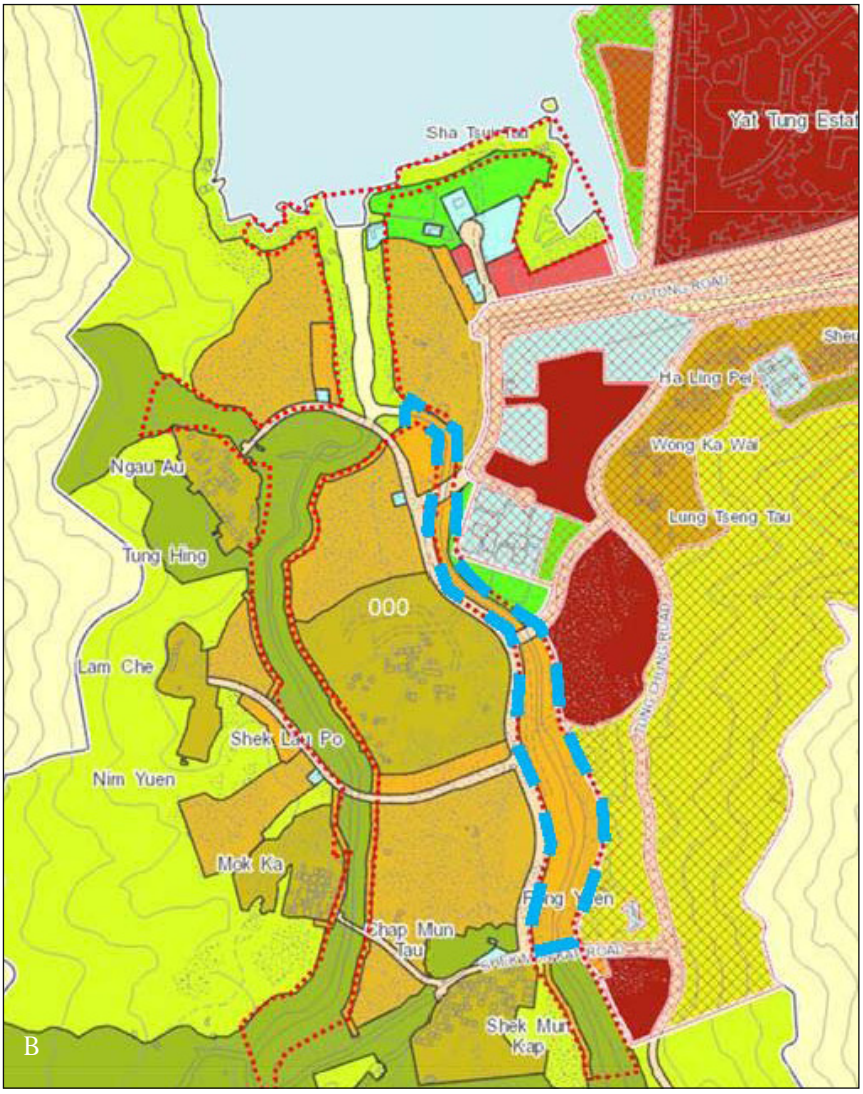

Figure 6. (A) Yat Tung Estate, Tung Chung West and (above) the Po Lin Monastery cable car (Ngong Ping Cable Car) running some 5.7 km from the southermost part of the airport platform to the Po Lin Monastry. Photo credit: Minghong [Wikimedia Commons]. (B) Map of the joint green group proposal to the Hong Kong SAR Government requesting that they extend their plans for a River Nature Park (blue dotted line) to cover both the eastern and western arms of the Tung Chung stream and the mangrove areas (red dotted lines) (Green Power et al. 2016). Link.

to be able to travel to a rare dragonfly site by way of one of the World's largest airports. The breeding site is only 1 km across the bay from the airport!

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New Books

Complete Field Guide to Dragonflies of Australia
Revised edition

Authors: Günther Theischinger & John Hawking
Illustrated by Albert Orr

Book announcement by
Günther Theischinger [theischingergunther@gmail.com]
The book is not expected to be released until later this year

The Complete Field Guide to Dragonflies of Australia (Theischinger & Hawking 2006) was first published by CSIRO Publishing 14 years ago. It has turned out to be a useful field guide; but owing to an unfortunate choice of cover photo, which I never endorsed, it could never be described as a beautiful book. This was reason enough for me never to like it, although in other respects CSIRO Publishing did an excellent job, and the book was reprinted 2010, 2012 and 2016, without however any significant revision. Despite its 'ugly duckling' appearance, the book certainly promoted interest in Australian Odonata. Since its publication there has been a significant increase in local dragonfly photographers and other enthusiasts, with several going on to become serious research odonatologists. It was in this context, and with the fifth edition of the field guide due in 2020, that I suggested that we should produce a fully revised edition. It was agreed that this time I could update the information and make other small alterations, including improving the quality of the colour illustrations.

In the last 14 years there have been several significant advances in our knowledge of Odonata, both world-wide and in Australia. On this continent we are particularly affected by changes in the accepted higher classification, based largely on recent molecular analysis that necessitated updating the treatment in this field guide.

Although by no means all issues of higher classification have been resolved, the policy in the revised guide is to adopt the multi-authored consensus on the higher classification of dragonflies based on the principles of stability and monophyly of family group taxa (Dijkstra et al. 2013, 2014). Thus the order of family group taxa in Australia is at least temporarily, and for better or worse, brought in line with that followed in the rest of the world. The single exception to this scheme is the recognition of the family Argiolestidae, which subsequent information clearly showed to be a monophyletic group.

In addition, since the publication of the book, one genus new to Australia has been discovered along with more than half a dozen new species, as well as six newly described species, five from eastern Australia (Theischinger 2008b, 2009, 2013, 2018, 2019; Theischinger & Burwell 2017, Rowe 2020) as well as two spectacular species from Dauan Island, an Australian possession in the Torres Strait, very close to the coast of New Guinea (De Baar et al. 2010). These are all incorporated into the new edition, along with new information made available in various books and larger papers that were published on several major regions of Australia: Southwest Australia (Taylor 2012), Pilbara, NW Australia (Taylor 2013), Southeast Queensland (Nattrass 2006), Victoria and Tasmania (Richter & Endersby, 2019), Eungella region in Queensland (Burwell et al., 2020), the Granite Belt region of Queensland (Burwell et al., in press), of the Murray Darling Basin (Theischinger et al. 2018).

There have been several significant changes in known geographic distribution, some possibly connected with global warming, reported by Endersby (2013, 2014), Haywood & Richter (2013), Haywood (2019), Kenway (2006), Richter (2013, 2014, 2016), Sands & Burwell (2009), Theischinger (2008a, 2009), Theischinger et al. 2011), Theischinger & Jacobs (2012), Theischinger et al. (2013). All are included in the book.

The book has received a significant facelift in terms of its visual appeal. Firstly, Albert Orr has provided 12 plates of watercolour art portraying 40 adult habitus representing all Australian families as well as four genera presently treated as *incertae sedis*. Two examples, showing *Petalura pulcherrima* and *Diphlebia hybridoides* are presented here. In addition Ray Andress, also a fine artist, depicts in life, *Petalura ingentissima*, one of the most spectacular dragonflies found anywhere in the world. These and live colour photos and larval habitus drawings of members of most Australian genera are included in the section "Identification" to enliven the dichotomous keys. Finally, since the initial publication of the book, rapid advances in digital photography now allow dragonflies to be photographed at an astonishingly high standard, even compared with 14 years ago. A total of about 150 new photographs are included in the book, thanks to contributions from Ros Coy, Vik Dunis, Leonard Mueller, Kerrie O'Donnell, Fons and Valentina Peels, Steve Richards, Reiner Richter, Petra Ries, Linda Rogan, Colin Trainor, Geoff Walker, and Graham Winterflood. This wealth of superb depictions of adult dragonflies and damselflies in life significantly improves the photographic representation of the fauna.

The book is expected to be released later this year. To be more precise would always have been difficult. It is even more difficult in these challenging times.

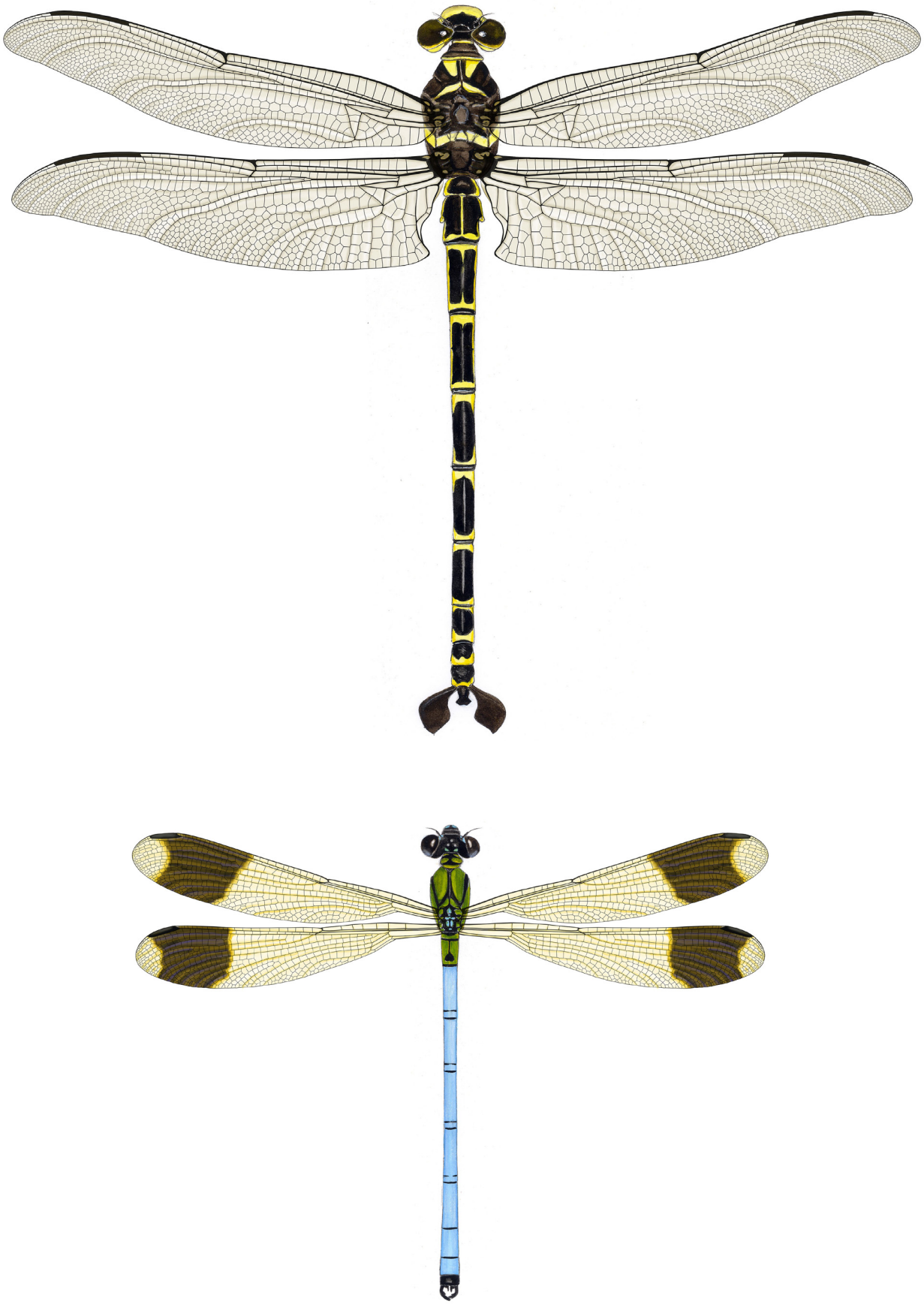

Figure 1. Two examples of the 12 plates of watercolour artworks by Albert Orr portraying 40 representative adults of the Australian families plus four genera presently treated as *incertae sedis*. (Top) *Petalura pulcherrima* (Petaluridae) and (bottom) *Diphlebia hybridoides* (Lestoideidae).

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Dragonflies at a biogeographical crossroads: The Odonata of Oklahoma and complexities beyond its borders

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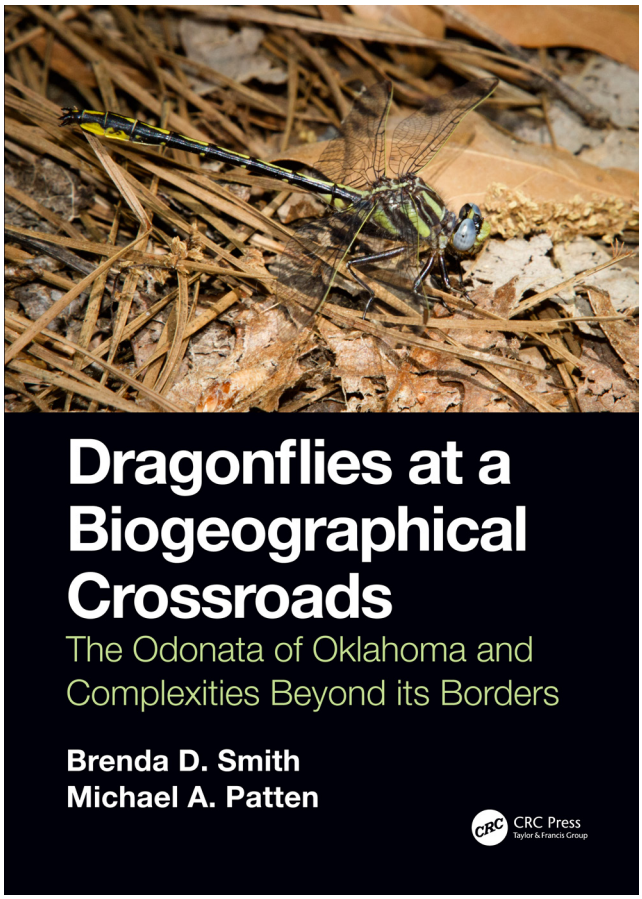

Dragonflies at a Biogeographical Crossroads is a unique approach to odonatology, and arguably, entomology. This lavishly illustrated book examines the distribution, ecology, conservation status, and biogeography of 176 species of odonates in a part of the United States where 12 ecoregions converge, making it inextricably linked with a wide swath of North America.

The book is highly data driven (>55,000 historical and contemporary records), but its visually creative way of considering topics such as phenotypic variation, ecology, and anthropogenic effects on odonates makes it approachable to natural historians, odonatologists, and dragonfly enthusiasts alike. Context-driven chapters, such as one on the region's rich paleo-entomological history, another on its environmental history, and another detailing odonatological research since 1877, give a fresh perspective on the natural world while providing a rich summary of the odonates.

This book is a fantastic contribution to the field. Not only does it present a great array of new information, it even presents new ways to present that information. I have never seen a book about the flora or fauna of a state that has as much information as this book contains. I paged through it in awe of the scholarship, thoroughness and even imagination expressed in the pages. The occurrence maps are fantastic, better than any I have ever seen, as they combine specimens, photos and sight records in an easily understandable way. As well, it often deals with taxonomic and other questions that far exceed the borders of the state. So many things about this book are unique! Conservation becomes a more and more important feature of our writing about odonates and other organisms, and this book treats that thoroughly.

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