# ICO 2023

## International Congress of Odonatology


# BOOK OF ABSTRACTS

25-30 June, 2023

Paphos, Cyprus

ICO 2023

International Congress of Odonatology

# BOOK OF ABSTRACTS

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Congress logo
The congress logo features a map of the Eastern Mediterranean including Cyprus with the island's speciality, *Ischnura intermedia* (Persian Bluetail), a scarce and localised damselfly that was only discovered on the island in 2013.

**ICO 2023 is organised by**:

The Cyprus Dragonfly Study Group and
Terra Cypria, the Cyprus Conservation Foundation, in conjunction with the Worldwide Dragonfly Association.

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Financial support for student member attendance has been generously provided by: Cyprus Dragonfly Study Group (CDSG), Dragonfly Society of the Americas (DSA), Gesellschaft deutschsprachiger Odonatologen (GdO), Worldwide Dragonfly Association (WDA).

The Cyprus Convention Bureau of the Cyprus Deputy Ministry of Tourism kindly contributed gifts for the delegates.

# ICO 2023
# International Congress of Odonatology
# 25-30 June, 2023, Paphos

### International Congress Organising Committee

John C. Abbott (USA), Kendra Abbott (USA), Richard Rowe (Australia), Javier Muzon (Argentina)

### ICO 2023 Organising Committee

David J. Sparrow (chair), Dinos Konis, Shane Marshall, Koulla Michael, Mary Michaelides, Rosalyn Sparrow, Heather Stroud, Dave Walker, Jan Walker

### Scientific Committee

Geert De Knijf, Vincent Kalkman, Andreas Martens, David J. Sparrow, Frank Suhling, Jessica Ware

### Webmaster

Kendra Abbott

### Travel Awards

Awards were provided to six students to support their attendance at ICO 2023:

Daniela Ayala-Sánchez (Colombia/Mexico), Ojonugwa Ekpah (Nigeria), Laura Anna Mähn (Germany), Diagal Wisnu Pamungkas (Indonesia), Daniel Schönberger (Sweden), Adam Tarkowski (Poland)

# Venue
# Registration
# Meals and Drinks

## Congress Venue

The Congress will be held in the amphitheatre of Neapolis University, which is located one floor down from the reception area.

## Registration

Registration will be open from 15.00 to 20.00 on Sunday 25 June and 08.00 to 08.45 on Monday 26 June in the reception area of the University. Congress bags will be available at this time.

## Meals and drinks

Breakfast will be served from 07.30 in the cafeteria for those staying at the University. Tea, coffee, water, fruit juice and light refreshments will be served at mid-morning and mid-afternoon breaks on each day of the congress. Lunch will also be provided.

During the mid-congress field trip, lunch will be provided at the Psilo Dendro Trout Farm Restaurant, in the mountain village of Platres, at 1300m asl which should give a break from the early afternoon heat.

The optional congress dinner will be held on Friday 30 June at 18.30 in the garden of the University.

Neapolis University is located in the Kato-Paphos tourist district and there are numerous restaurants available for dining on free evenings.

# Programme at a glance

## Sunday 25 June

15.00 – 20.00 Registration
18.00 – 20.00 Welcome drinks

## Monday 26 June

08.00 – 08.45 Late registration
08.45 – 09.30 Welcome to Cyprus and introductions
09.30 – 10.30 **Session 1: Dragonflies on islands**
10.30 – 11.00 Refreshment break
11.00 – 12.20 Session 1 (continued)
12.20 – 13.30 Lunch
13.30 – 15.10 **Session 2: Biogeography**
15.10 – 15.40 Refreshment break
15.40 – 17.20 Session 2 (continued)
17.45 – 19.00 Wine tasting

## Tuesday 27 June

08.45 – 09.00 Housekeeping
09.00 – 10.40 **Session 3**: **Conservation**
10.40 – 11.10 Refreshment break
11.10 – 12.50 Session 3 (continued)
12.50 – 14.00 Lunch
14.00 – 15.40 Session 3 (continued)
15.40 – 16.10 Refreshment break
16.10 – 17.10 Workshop: Beyond P-value
17.10 – 18.10 IUCN Meeting

# Programme at a glance

## Wednesday 28 June

| | |
|---|---|
| 08.45 – 09.00 | Housekeeping and briefing for the mid-congress field trip |
| 09.00 – 10.40 | **Session 4: Phylogenetics, Systematics and Taxonomy** |
| 10.40 – 11.10 | Refreshment break |
| 11.10 – 12.50 | Session 4 (continued) |
| 12.50 – 14.00 | Lunch |
| 14.00 – 15.00 | Poster session |
| 15.00 – 15.30 | Refreshment break |
| 15.30 – 17.00 | WDA Biennial meeting |

## Thursday 29 June

| | |
|---|---|
| | Mid-congress field trip |
| 08.15 | Coaches depart from Paphos Gardens Hotel |
| 08.30 | Coaches depart from Neapolis Hotel |

## Friday 30 June

| | |
|---|---|
| 08.45 – 09.00 | Housekeeping |
| 09.00 – 10.40 | **Session 5: Climate Change** |
| 10.40 – 11.10 | Refreshment break |
| 11.10 – 12.10 | Session 5 (continued) |
| 12.10 – 12.50 | **Session 6: Ecology and ethology** |
| 12.50 – 14.00 | Lunch |
| 14.00 – 15.20 | Session 6 (continued) |
| 15.20 – 15.50 | Refreshment break |
| 15.50 – 17.00 | Winding up |
| 18.30 | Congress dinner |

# FULL PROGRAMME

**ICO 2023**

**International Congress of Odonatology**

**25-30 June, 2023, Paphos, Cyprus**

## SUNDAY 25 JUNE

15.00 – 20.00 Registration in Neapolis University reception area
18.00 – 20.00 Welcome drinks in the University cafeteria

## MONDAY 26 JUNE

08.00 – 08.45 Registration
09.00 – 09.10 Introductory remarks and introduction of delegates
09.10 – 09.30 Introduction to Cyprus
*Rosalyn Sparrow and David J. Sparrow*

**Session 1: Dragonflies on islands** Chair: Jessica Ware

09.30 – 10.10 Plenary lecture: A theory of island odonatography
*Andreas Martens (Ab. 22)*

10.10 – 10.30 Dragonflies on oceanic and sky islands face similar challenges
*Michael J. Samways, Charl Deacon & James S. Pryke (Ab. 31)*

**10.30 – 11.00 Refreshment break**

11.00 – 11.20 Interplay between pond size and matrix extent drives dragonfly diversity patterns in a fragmented landscape
*Charl Deacon, Michael J. Samways & James S. Pryke (Ab. 5)*

11.20 – 11.40 Phenology of the Odonata of the Maltese Islands
*Charles Gauci (Ab. 8)*

11.40 – 12.00 Dragonflies and damselflies of Cyprus: their amazing underwater stages
*Christophe Brochard (Ab. 3)*

12.00 – 12.20 Monitoring the dragonflies of Cyprus
*David J. Sparrow, Geert De Knijf & Rosalyn Sparrow (Ab. 35)*

**12.20 – 14.00 Lunch**

**Session 2: Biogeography** Chair: Vincent Kalkman

13.30 – 14.10 Plenary lecture: Diversity of Nearctic and Palaearctic Dragonflies and Damselflies
*John C. Abbott, Vincent Kalkman, Cornelio A. Bota-Sierra, Jean-Pierre Boudot, Ryo Futahashi, Enrique González-Soriano, Rodolfo Novelo-Gutiérrez, Robert Guralnick, Seth Bybee, Jessica Ware & Michael W. Belitz (Ab. 1)*

14.10 – 14.30 Historical Biogeography in the Neotropics an overview from the banner-winged and ruby-spot damselflies
*Melissa Sanchez Herrera & Samantha Standring (Ab. 32)*

14.30 – 14.50 Timing and direction of faunal exchange between Neartic and Palaeartic in Odonata
*Maria Pàmies-Harder, Cesc Múrria, John Abbott, Kendra Abbott & Vincent J. Kalkman (Ab.27)*

14.50 – 15.10 Diversity and distribution patterns of the dragonflies and damselflies of Suriname
*Karin Verspui, Marcel Wasscher & Peter van Horssen (Ab. 47)*

**15.10 – 15.40 Refreshment break**

15.40 – 16.00 Annual patterns of emergence and population sizes in Gomphidae: an overview
Frank Suhling & Mike Averill *(Ab. 36)*

16.00 – 16.20 Status and distribution of Nigerian Odonata from confirmed county-level data for two decades
*Ojonugwa Ekpah, Kehinde A. Kemabonta, Sylvester S. Ogbogu, Babasola W. Adu, Azeezat O. Alafia, Bibitayo A. Owolabi & Abiodun M. Adedapo (Ab. 6)*

16.20 – 16.40 Distribution records of Javan endemic Odonata with notes on habitat characteristics for: *Heliogomphus drescheri* & *Rhinocypha heterostigma*
*Diagal Wisnu Pamungkas, Amelia Nugrahaningrum, Wahyu Sigit Rahadi, Hening Triandika Rachman, Nanang Kamaludin & Frendi Irawan (Ab. 28)*

16.40 – 17.00 Indian Dragonflies (Odonata) with special emphasis on the Doon Valley fauna and conservation
*Brij Kishore Tyagi (Ab. 43)*

17.00 – 17.20 Urbanization effects on life history traits in the damselfly *Ischnura elegans*
*Gemma Palomar, Guillaume Wos, Robby Stoks & Szymon Sniegula (Ab. 26)*

**17.45 – 19.00 Wine tasting and student mixer**

## TUESDAY 27 JUNE

08.45 – 09.00 Housekeeping

**Session 3: Conservation** Chair: Andreas Martens

09.00 – 09.40 Plenary lecture: From records to conservation
*Roy van Grunsven (Ab.45)*

09.40 – 10.20 A new Red List of the dragonflies and damselflies of Europe
*Geert De Knijf , Magnus Billqvist, Roy van Grunsven, Florent Prunier & Damjan Vinko (Ab. 4)*

10.20 – 10.40 Northern shift of Odonata and decline of Mediterranean river species in Spain and Portugal
*Florent Prunier, Martiño Cabana, Adolfo Cordero-Rivera, Cecilia Díaz-Martínez, Adrià Miralles-Núñez, Pere Luque, Carmen Díaz Paniagua, Albano Soares, Geert De Knijf, Magnus Billqvist, Damjan Vinko & Roy van Grunsven (Ab. 29)*

**10.40 – 11.10 Refreshment break**

11.10 – 11.30 Using environmental DNA to assess rare dragonflies
*Kendra Abbott, Kevin Kocot & John Abbott (Ab. 2)*

11.30 – 11.50 First insight into the DRAGON project: Dragonflies as bellwether for the human **i**mpact on interface ecosystems
*Martin Jeanmougin, Reto Schmucki & Colin Fontaine (Ab. 14)*

11.50 – 12.10 Sum or mean? Calculation problem of the Dragonfly Biotic Index, and the novel R package for its solution
*Hana Šigutová, Petr Pyszko, Veronika Prieložná, Eva Bílková & Aleš Dolný (Ab. 34)*

12.10 – 12.30 Dragonfly diversity patterns at the landscape scale – comparison between urban, agricultural and more natural landscapes
*Diana Goertzen (Ab. 9)*

12.30 – 12.50 Post-mining sites as ecological traps for dragonflies
*Filip Harabiš , Anna-Marie Poskočilová, Adam Tetaur & Marketa Josková (Ab. 11)*

**12.50 Group photograph**

**13.00 – 14.00 Lunch**

**Conservation (continued)** Chair: Geert De Knijf

14.00 – 14.20 Environmental drivers shaping Odonata assemblages in a Ramsar declared floodplain wetland in South-Eastern Europe
*Marina Vilenica, Andreja Brigić, Viktorija Ergović, Miran Koh, Antun Alegro, Vedran Šegota, Anja Rimac, Mario Rumišek & Zlatko Mihaljević (Ab. 48)*

14.20 – 14.40 Population abundance and structure of dragonflies: does the concentration of nitrates and orthophosphates matter?
*Agnieszka Tańczuk (Ab. 38)*

14.40 – 15.00 Of mice and men
*Dušan Šácha (Ab. 30)*

15.00 – 15.20 Peat pools - a rescue wheel for aquatic fauna in drying peatlands, based on the example of dragonflies (Odonata)
*Adam Tarkowski (Ab. 39)*

15.20 – 15.40 Conservation of the threatened *Lestes macrostigma*: from detailed ecology to habitat management and restoration
*Philippe Lambret & Robby Stoks (Ab. 20)*

**15.40 – 16.10 Refreshment break**

16.10 – 17.10 Workshop: Beyond P-value: effect size estimation and visualization with Durga R package
*Md Kawsar Khan*

17.10 – 18.10 IUCN meeting

**Free Evening**

## WEDNESDAY 28 JUNE

08.45 – 09.00 Housekeeping and briefing for the mid-congress trip

### Session 4: Phylogenetics, Systematics and Taxonomy

Chair: Steve Jordan

09.00 – 09.40 Ordinal level phylogenomics of Odonata based on anchored hybrid enrichment
*Lacie G. Newton, John C. Abbott, Seth M. Bybee, Paul B. Frandsen, Aaron Goodman, Robert Guralnick, Vincent J. Kalkman, Judicael F. Lontchi, Pungki Lupiyanigdyah, Melissa Sanchez-Herrera, Laura Sutherland, Ethan Tolman, Rhema Uche-Dike & Jessica L. Ware (Ab. 24)*

09.40 – 10.00 Evolutionary history and divergence times of Odonata (dragonflies and damselflies) revealed through transcriptomics
*Manpreet Kohli & Jessica Ware (Ab. 18)*

10.00 – 10.20 Mitochondrial DNA markers and their limitations in Odonata research
*Stanislav Ožana, Tomáš Pánek & Aleš Dolný (Ab. 25)*

10.20 – 10.40 Systematics of Synthemistidae and Corduliidae (Anisoptera: Libelluloidea)
*Aaron Goodman & Jessica Ware (Ab. 10)*

**10.40 – 11.10 Refreshment break**

11.10 – 11.30 Phylogenomics, population structure and behaviour of *Neurocordulia*
*Jessica L. Ware, Patrick Hulick, Angelo Soto Centeno, Manpreet Kohli & Ethan Tolman (Ab. 49)*

11.30 – 11.50 Assessing and resolving relationships within family Macromiidae using targeted enrichment
*Rhema Uche-Dike & Jessica Ware (Ab. 44)*

11.50 – 12.10 New descriptions of *Micrathyria venezuelae* and *Oxyallagma dissidens* exuviae
*Matthias Hartung (Ab. 12)*

12.10 – 12.30 Modelling Past and Present Population Dynamics of the Black Petaltail Dragonfly
*Ethan Tolman, Christopher D. Beatty, Jonas Bush, Aaron Goodman & Jessica Ware (Ab. 40)*

12.30 – 12.50 The X chromosome of insects predates the origin of Class Insecta
*Melissa A. Toups & Beatriz Vicoso (Ab. 41)*

**12.50 – 14.00 Lunch**

14.00 – 15.00 Poster session

**15.00 – 15.30 Refreshment break**

15.30 – 17.00 WDA bi-annual meeting

**Free Evening**

## THURSDAY 29 JUNE

08.30 Mid-congress field trip. Coaches depart from Neapolis University

**Free Evening**

## FRIDAY 30 JUNE

08.45 – 09.00 Housekeeping

**Session 5: Climate Change** Chair: Frank Suhling

09.00 – 09.40 Plenary lecture: Potential effects of climate change on distribution and ecological interactions in Odonata
*Frank Johansson (Ab. 15)*

09.40 – 10.00 Development of two common dragonfly species with diverging occupancy trends
*Jolan Hogreve (Ab. 13)*

10.00 – 10.20 Bivoltinism in the univoltine *Lestes sponsa*? Possible effect of water management and climate change
*Philippe Lambret, Szymon Śniegula & Ulf Norling (Ab. 19)*

10.20 – 10.40 Transcriptomics reveals high phenotypic plasticity of *Coenagrion puella* to experimentally induced temperature changes
*Cesc Múrria, Alba Julià-López, Carla Fernández, Xavier Maynou & Cinta Pegueroles (Ab. 23)*

**10.40 – 11.10 Refreshment break**

11.10 – 11.30 Climate change impact on damselfly-parasite interactions
*Md Kawsar Khan (Ab. 17)*

11.30 – 11.50 Climate stability is a key driver of difference in the global richness of lentic and lotic odonates
*Laura A. Mähn, Klaas-Douwe Dijkstra, Christian Hof, Roland Brandl & Stefan Pinkert (Ab. 21)*

11.50 – 12.10 Impacts of climate change on dragonflies and damselflies in West and Central Asia
*Vincent J. Kalkman, John Cadena & Leon Marschall (Ab. 16)*

**Session 6: Ecology and ethology** Chair: Klaus-Jürgen Conze

12.10 – 12.50 Plenary lecture: For the love of demoiselles: tips they have taught me for the next generation
*Ola M. Fincke (Ab. 7)*

**12.50 – 14.00 Lunch**

14.00 – 14.40 Ecology, behaviour and speciation in *Mnais* damselflies
*Yoshitaka Tsubaki (Ab. 42)*

14.40 – 15.00 Disentangling the evolution of the metabolic allometry in dragonflies and damselflies (Odonata)
*Daniel Schönberger, Moa Metz & Erik I. Svensson (Ab. 33)*

15.00 – 15.20 Novel hatching cue in the neotropical damselfly *Megaloprepus caerulatus*: larval adaptation and maternal constraint
*Arjèn van't Hof & Ola M. Fincke (Ab. 46)*

15.20 – 15.40 To hunt or to hide - effects of chemical cannibalistic cues on individual behavior – *Ischnura elegans* as a model
*Monika Sysiak, Matylda Kubiak, Barbara Pietrzak, Anna Bednarska, Andrzej Mikulski (Ab. 37)*

**15.40 – 16.10 Refreshment break**

**16.10 Winding up**

An Invitation to ECCO 2024: Florent Prunier
An invitation to ICO 2025: Melissa Sanchez Herrera

Thanks and acknowledgements

# ABSTRACTS (ORAL PRESENTATIONS)

**ICO 2023**

**International Congress of Odonatology**

**25-30 June, 2023, Paphos, Cyprus**

# 1 Diversity of Nearctic and Palaearctic Dragonflies and Damselflies

John C. Abbott[1], Vincent Kalkman[2], Cornelio A. Bota-Sierra[1,3], Jean-Pierre Boudot[4], Ryo Futahashi[5], Enrique González-Soriano[6], Rodolfo Novelo-Gutiérrez[7], Robert Guralnick[8], Seth Bybee[9], Jessica Ware[10] & Michael W. Belitz[8]

[1]Alabama Museum of Natural History & UA Museums Department of Research and Collections, The University of Alabama, Tuscaloosa, AL 35487, USA
[2]Naturalis Biodiversity Center, 2300 RA Leiden, The Netherlands
[3]Grupo de Entomología Universidad de Antioquia (GEUA), Universidad de Antioquia, Medellin 50010, Colombia
[4]IUCN Odonata Specialist Group, 54710 Ludres, France
[5]Bioproduction Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Central 6, Tsukuba 305-8566, Japan
[6]Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 70-153, Mexico City 04510, Mexico
[7]Department of Biology and Monte L. Bean Museum, Brigham Young University, Provo, UT 84602, USA; seth.bybee@gmail.com
[8]Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, USA
[9]Department of Biology and Monte L. Bean Museum, Brigham Young University, Provo, UT 84602, USA
[10]Division of Invertebrate Zoology, American Museum of Natural History, New York, NY 10024, USA

**Keywords:** biodiversity and conservation; biogeographical patterns; distribution; glaciation; species occurrence

Species distribution models (SDMs) were created for 509 Nearctic and 402 Palaearctic species of dragonflies and damselflies (Odonata). Species occurrence data were assembled by reviewing databases of specimens held by significant Odonata repositories and through an extensive search of literature references for the whole of the Nearctic and Palaearctic (excluding China and the Himalayan region). Species were categorized as forest-dependent or non-forest-dependent (Nearctic only), as lentic or lotic-dependent, and according to conservation status. Predicted distributions were stacked for all species across their entire ranges, including areas outside of the Nearctic and Palaearctic. Species richness and corrected weighted endemism (CWE) were then calculated for each grid cell. We found a pattern of greater species richness in the eastern portion of the Nearctic, which can be explained by the higher aquatic

habitat diversity at micro and macroscales east of the Rocky Mountains, promoting niche partitioning and specialization. In the Nearctic region, the southeastern US has the highest number of endemic species of dragonflies and damselflies; this degree of endemism is likely due to glacial refuges providing a foundation for the evolution of a rich and unique biota. In the Palaearctic, these maps show a clear pattern of decreasing diversity longitudinally, with species numbers dropping in the eastern half of Europe and remaining low throughout a large part of Russia, then increasing again towards Russia's Far East and Korea. Areas with a high diversity of species assessed as threatened on the IUCN red list are largely restricted to the Mediterranean, Southwest Asia, and Japan, with clear hotspots found in the Levant and the southern half of Japan.

## 2 Using environmental DNA to assess rare dragonflies

Kendra Abbott[1], Kevin Kocot[1,2] & John Abbott[2]

[1]The University of Alabama, Department of Biological Sciences
[2]Alabama Museum of Natural History & Department of Research and Collections

**Keywords:** Odonata, Anisoptera, environmental DNA, globally rare species

Freshwater habitats are critically important to biodiversity, but many of these habitats and the organisms living within them are under threat. For one of the most popular and ecologically important groups of aquatic insects, dragonflies (Odonata: Anisoptera), we assessed ancestral and current population sizes, for four species of concern (*Somatochlora margarita, Cordulagaster sarracenia*, *Ophiogomphus australis* and *Phanogomphus hodgesi*) in the southern United States. Finally, we conducted a preliminary experiment to determine how far and how long odonate DNA persisted in an intermittent stream. We then used environmental DNA to determine additional locations of four species that are both locally and globally rare *or* rarely encountered where more information was needed.

## 3 Dragonflies and damselflies of Cyprus: their amazing underwater stages

Christophe Brochard
Bureau Biota, Zwolle, The Netherlands

**Keywords:** larva identification, larva ecology, larval behavior, summer survival, conservation

When going to Cyprus, you can encounter wonderful species of damselflies and dragonflies such as *Epallage fatime, Ischnura intermedia, Anax immaculifrons* … to mention a few. Unfortunately, very little is known about their larval stage. In this presentation you will dive into the secret and fascinating underwater part of their lives. Not only identification, ecology and behavior will be highlighted. You will discover where to find them and how they survive dry summers. Finally, a focus will be made on their conservation and how fragile they are at this stage.

# 4 A new Red List of the dragonflies and damselflies of Europe

Geert De Knijf [1,2], Magnus Billqvist[3], Roy van Grunsven [2,4], Florent Prunier[5] & Damjan Vinko[6]

[1] Research Institute for Nature and Forest (INBO), Brussels, Belgium
[2] IUCN Dragonfly Specialist Group
[3] Swedish Society for Conservation of Nature in Scania, Sweden
[4] Dutch Butterfly Conservation, Wageningen, the Netherlands
[5] Red de Observadores de Libélulas en Andalucía (ROLA)
[6] Slovene Dragonfly Society, Ljubljana, Slovenia

**Keywords:** Odonata, conservation, IUCN, threats, trends

The IUCN Red List criteria are intended to classify species according to their extinction risk. To be an accurate and up-to-date policy instrument, the Red List should ideally be revised every 10 years. The first European Red List of Odonata, published in 2010, was based on expert opinion rather than on trend analysis. The main reason was the absence of an extended database from Europe. In 2015 a European Atlas was published based upon a compiled database. Since then, a lot of new data of odonates have become available, also from some previously rather under-surveyed regions, such as Iberia, Scandinavia and to some extent the western Balkans. Furthermore, some new species have since been discovered in Europe (e.g. *Onychogomphus cazuma*), increasing the total number of species from 137 in 2010 to 147 in 2023.

In the new Red List we have used trend estimates to assess the possible decline of a species. All together no less than 29 species (21%) are threatened (Critically Endangered, Endangered or Vulnerable) and an additional 18 species (12%) are Near Threatened. This means that one third of the European odonate species is now to some degree threatened, with nearly the same results for the assessment at the European Union level. Most remarkable is that nearly all species confined to bogs and oligotrophic waters are now threatened in Europe, while in the previous Red List nearly all were categorized as Least Concern. Many species of Mediterranean running waters are still threatened, as was the case in the previous version. Due to much more data and knowledge, several species (e.g. *Coenagrion ornatum*, *Cordulegaster bidentata*) are no longer threatened in Europe.

# 5 Interplay between pond size and matrix extent drives dragonfly diversity patterns in a fragmented landscape

Charl Deacon[1], Michael J. Samways[1] & James S. Pryke[1]

[1]Department of Conservation Ecology and Entomology, Faculty of AgriSciences, Stellenbosch University, South Africa

**Keywords:** pondscape, lentic habitats, biodiversity hotspot, transformed landscapes, dragonfly traits

Landscape fragmentation impacts freshwater habitats and their quality, affecting aquatic insect assemblages. Adjacent terrestrial areas are important secondary habitats where many aquatic insects mature, feed, find mates, and move to locate aquatic breeding habitats. Using dragonflies as model organisms, we investigate 1) how pond size/terrestrial patch size interaction affects overall odonate diversity patterns versus habitat quality variables, and 2) determine whether anisopterans and zygopterans respond differently to landscape fragmentation. In an exotic tree plantation-fragmented landscape of sub-tropical southern Africa, we used a factorial design with 27 small and large ponds within small and large patches of the surrounding matrix. We compared the importance of pond and patch size interplay relative to habitat quality variables in driving lentic odonate diversity patterns and biological trait representation in this transformed landscape. Species richness was similar among ponds. However, odonate abundance was highest in large ponds regardless of terrestrial patch size. Zygopteran functional richness and diversity was driven by pond size, implying that zygopterans are sensitive to landscape fragmentation. In contrast, anisopterans were more resilient and more likely to select suitable habitats based on water chemistry and vegetation characteristics. The various pond categories were occupied by compositionally dissimilar odonate assemblages, and occupancy was strongly associated with mobility traits. As such, ponds in small terrestrial patches have equal conservation value compared to those in large patches. A pondscape with many pond sizes is important for representing regional odonate diversity. The results presented here emphasize that pond conservation needs to be considered in the wider terrestrial context, which host a range of important secondary habitats. These adjacent terrestrial habitats also connect nearby aquatic habitats, and enable insects to move across the landscape in response to natural and artificial stressors.

# 6 Status and distribution of Nigerian Odonata from confirmed country-level data for two decades

Ojonugwa Ekpah[1], Kehinde A. Kemabonta[2], Sylvester S. Ogbogu[3], Babasola W. Adu[4], Azeezat O. Alafia[5], Bibitayo A. Owolabi[6] and Abiodun M. Adedapo[3]

[1]Nigerian Conservation Foundation, Nigeria
[2]University of Lagos, Akoka, Nigeria
[3]Obafemi Awolowo University, Ile-Ife, Osun state, Nigeria
[4]Federal University of Technology, Akure, Nigeria
[5]Lagos State University, Nigeria
[6]Osun State University, Nigeria

**Keywords:** Odonata, record, substratum, endangered, distribution

The heterogeneity of Nigerian habitats supports a variety of species of dragonflies and damselflies, some of which are endemic and relic. Apart from their role as bioindicators of ecological health, Nigerian Odonata, especially the endemic and rare species are instruments of ecotourism. All confirmed, country-level odonate data from literature were compiled. This dataset contains 218 records from a total of 20 sites of protected and unprotected habitat types in Nigeria. African Dragonfly Biotic Index (ADBI) score was calculated separately for the 20 sites. Oban Hills and Afi Mountains (in Cross River State) scored high with 109 and 130 respectively. Aponmu in Akure Forest Reserve (in Ondo State) had the highest ADBI of 216. Some species of Odonata such as *Ceriagrion glabrum* (Burmeister, 1839) and *Orthetrum stemmale* (Burmeister, 1839) were widespread, found in 11 and 15 of the 20 sites respectively. Some species, such as *C. citrinum* (Campion 1914) were restricted to only one ecoregion. Distribution maps for endemic and relic species of Nigerian Odonata are drawn using ArcGIS. Odonata hot-spots were indicated, which could help identify conservation priority sites and to monitor habitat dynamics due to anthropogenic activities.

# 7 For the love of demoiselles: tips they have taught me for the next generation

Ola Fincke
Department of Biology, University of Oklahoma, Norman OK, USA

**Keywords:** *Ischnura*, *Enallagma*, Pseudostigmatinae, signal apparency

Having lived with odonates for nearly a half century, I highlight some advice for the younger generation of field ecologists and behaviorists using odonates as study species. Marking a damselfly transforms a species into an individual, a requirement for the most rigorous measures of evolutionary fitness. Following such individuals in the wild is time-consuming, but this method offers the most durable, reliable results for testing many hypotheses. Only after following individual *Ischnura elegans* did we falsify long-held hypotheses that learning by sexually mature males (via search image formation or associative learning) maintains female-specific color polymorphism in non-territorial species. Direct measures of harassment of free-flying female color morphs supported the Ideal-free Signal Apparency hypothesis for both *Ischnura elegans* and *Enallagma hageni*, offering a more subtle means of genetic maintenance in these populations.

Tropical odonates are amongst the most understudied, offering the most original and timely work as anthropomorphic climate change threatens what we have yet to learn. Using neotropical damsels that breed in tree holes, I show how integrating behavioral and community ecology (along with much-needed physiological and biogeographical research) is key to understanding their biology and conservation. Tropical and temperate field stations offer enormous benefits for investigators in terms of logistical support, data collection, and collaboration. Particularly helpful are stations on islands, or field sites that act as islands (e.g. tepuis, isolated ponds, gallery forests, wildlife corridors), which increase the probability of re-sighting marked individuals. Increasingly, modern technology and molecular techniques offer ways of tracking individuals, particularly females, which have traditionally been the more difficult sex to study in the wild, but the most important in colonizing new habitats. Boldness, persistence, and international collaboration should offer exciting results for young behavioral and community ecologists. Choose study species you can love and respect, and collaborators that make field biology fun!

# 8 Phenology of the Odonata of the Maltese Islands

Charles Gauci

**Keywords:** checklist, flight periods, multi-voltine; trends

The results of this paper are based on year-round monitoring of a number of sites, mainly by the author, during the 10-year period 2013-2022. 20 species of odonata are on the Maltese Islands' checklist. However, only 11 species are recorded annually. Except for *Orthetrum coerulescens* which prefers lotic waters and seepages, the other 10 are habitat generalists, which is to be expected on a small archipelago lacking mountains, forests, rivers and lakes. Five old records of *Calopteryx* – 3 *virgo* and *2 haemorrhoidalis*, are of dubious origin while in the fourteen years that I have been studying dragonflies, I have never come across *Orthetrum brunneum* which I consider to be either extinct or, possibly, misidentified. *Pantala flavescens*, first recorded in 2013, appeared in relatively large numbers in 2022 and bred successfully. The other 5 species – *Aeshna mixta, Orthetrum chrysostigma, O. nitidinerve, Sympetrum striolatum,* and *Trithemis kirbyi* are either vagrants or very rare. For most species, flight periods are longer than those given in most guides covering areas which include the Mediterranean. This results from most species being multi-voltine. Interestingly three migrant species – *A. parthenope, A. ephippiger* and *S. fonscolombii* have autumn peaks similar to those in nearby south-eastern Sicily. Imago totals for all species demonstrate very wide annual fluctuations and, although this does not seem to be directly related to the amount of annual rainfall, it is closely related to reservoirs filling up at the right time. Early autumn rains provide suitable habitat for the three migrant species whereas lack of rain in spring greatly restricts the habitat available for breeding. *O. cancellatum*, which was never very common, seems to be on its way to local extinction while *O. trinacria* and *T. annulata*, which became established early this century, continue to show a steady increase.

# 9 Dragonfly diversity patterns at the landscape scale – comparison between urban, agricultural and more natural landscapes

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**Keywords:** land use, urbanisation, agriculture

Land use change and intensification by urbanisation and agriculture are major threats for freshwater biodiversity, e.g. due to loss and degradation of wetlands. However, Central European studies on dragonfly diversity in urban environments proved species diversity comparable to near natural landscapes as well as high conservation potential, while lowest diversity in agricultural landscapes was indicated. In most studies, "dragonfly diversity" is used in terms of taxonomic species richness and species composition. For better understanding of biodiversity patterns and evaluation of biodiversity and conservation potential of landscapes with intensive land use it is helpful to also integrate further components of biodiversity like trait (functional) diversity or phylogenetic diversity.

Therefore, I compared taxonomic diversity with these other facets of biodiversity between major land cover types in Germany comprising urban areas (URB), intensive agriculture (AGR) and more natural land cover (NAT, including forests) at the landscape scale. First results indicate that taxonomic richness was highest in NAT, lowest in AGR and intermediate in URB. Trait richness did not differ significantly between all groups, while phylogenetic richness was lower in NAT compared to URB and AGR. We further aim to analyse whether and how different land use affects dragonfly species with specific traits or trait combinations.

# 10 Systematics of Synthemistidae and Corduliidae (Anisoptera: Libelluloidea)

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**Keywords:** Tigertails, Emeralds, anchored hybrid enrichment, phylogenetics, 'GSI' clade

Synthemistidae Tillyard, 1911 is the smallest family and is sister to the remaining Libelluloidea (28 genera, 150 species), whose members are predominantly stream-dwelling Australasian endemics. Low phylogenetic support within Synthemistidae in prior studies was likely due to a lack of enough molecular data, and placement of tentative species fluctuates between Synthemistidae, and its sister family Corduliidae (Emeralds) due to low molecular resolution. The aim of this project is to resolve the systematics of Synthemistidae and Corduliidae by utilizing Anchored Hybrid Enrichment (AHE) probes which give phylogenetic signal at genus level resolution. Currently, we have sequenced all genera of both families except for three genera from Corduliidae and one within Synthemistidae, with over 60% species coverage (**Synthemistidae:** 94 species sequenced/150 total sequenced, **Corduliidae**: 115/165.

## 11 Post-mining sites as ecological traps for dragonflies

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**Keywords:** ecological traps, habitat selection, rapid environmental changes, restoration

Human-induced rapid environmental changes are occurring at significantly faster rates than natural processes, and animals increasingly encounter conditions they have not experienced in their evolutionary history. Odonates use one or several habitat quality indicators (proxy cues) to assess the quality of the environment. However, due to a sudden anthropogenic disruption, formerly adaptive cues may become maladaptive. Post-mining areas are often considered secondary biodiversity hotspots for freshwater insects. However, from the point of view of origin and subsequent development, they have many attributes to become ecological traps. To distinguish ecological traps from natural source-sink dynamics, we have to prove that their real quality does not correspond to their attractiveness. Therefore, structurally "optimal" restored habitats are more attractive than their natural alternatives. Therefore, the framework of our pilot experiment consisted of two parts. In the first part, we tested the hypothesis of whether structurally "optimized" restored habitats are more attractive than their natural alternatives. In the second part we compared several population parameters (survival, immunity or fat content) indicating larval performance in both restored and natural habitats. Based on the results of the transplant experiment (a total of 420 larvae of the model species *Sympetrum vulgatum*), it was obvious that individuals in post-mining sites suffered from higher mortality and were in worse body condition. At the same time, the attractiveness of natural habitats was higher than that of restored habitats. Overall, therefore, post-mining habitats function more like true sink habitats, although a few of them fulfill the potential to become ecological traps.

# 12 New descriptions of *Micrathyria venezuelae* and *Oxyallagma dissidens* exuviae

Matthias Hartung

**Keywords**: exuvia, Odonata, Venezuela, Ecuador, Peru, Colombia

*Micrathyria venezuelae* is a species of medium to high elevations in the Northern Cordilleras in Venezuela. The larva of *M. venezuelae* was hitherto unknown. Based on exuviae of several reared specimens, the final instar larva of *M. venezuelae* is described. Exuviae of *M. venezuelae* have two parallel rows of dark spots on the dorsum of the abdomen, lack mid-dorsal hooks, and the lateral spines on S9 are short; the thorax, tibiae, and femora have three dark bands each; the prementum has 9-13 setae and the labial palps 8-11 setae. A modified differentiation to known larvae of *Micrathyria aequalis* from *M. venezuelae* is provided.

*Oxyallagma dissidens* is a species of high elevations 2600-2700m in Ecuador and Peru. The larva of *O.dissidens* was hitherto unknown. Based on exuviae of reared specimens, the final instar larva of *O. dissidens* is described. Exuviae of *O. dissidens* have two parallel rows of dark spots on the dorsum of the abdomen, the prementum has 5-6 setae and the labial palps 6 setae. Antenna 7-segmented, distal margin of labial palp with four crenulations and a large spine. Head brownish and between the eyes at the front with a light band with three loops to behind. Pterothorax with parallel stripes on the wing bags at the inner side. Metathoracic femur length 2.75 mm. All femora with four darker edges with fine spines. Abdominal dorsum with fine punctuations and with a darker brownish distal half. *O. dissidens* has a comparable strong armation on the femurs. The gill lamellae have a medial broad dark brown vein, with several veins at all sides to the border of gills. In one case a description on *O. dissidens* was not given, but a figure was published. *O. dissidens* was mentioned from Peru (Quito, La Granadilla) and from Ecuador (Lago San Pablo, Campos of Guayaquil). *O. dissidens* is the recent name in contrast to the alternative name *runtuni*. Bota-Sierra and Andrés described *Oxyallagma olombianum* as new species of the genus from Colombia.

The habitats and other additional information will be given. Some information to the methods is included.

# 13 Development of two common dragonfly species with diverging occupancy trends

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**Keywords:** climate change, egg development, larval growth, phenological shifts

*Sympetrum vulgatum* and *S. striolatum* are very similar in their ecological niches, closely related, and widespread and common species in Central Europe. While *S. striolatum* shows strong positive population trends and is spreading northwards, *S. vulgatum* is declining. The causes of these opposing trends are not yet known. It is suspected that the trends are at least influenced by the recent climate change.

We present a study aiming to identify possible causes for the diverging trends. After a literature review, we decided to look in more detail at egg and larval development under different environmental conditions. The two species seem to prefer different oviposition sites, which means that especially eggs of *S. vulgatum* deposited in drying water areas might suffer from drought. Furthermore, both species have different overwintering strategies. To understand the influence of drought and direct vs. delayed egg development, the development of ten clutches of *S. striolatum* and eleven clutches of *S. vulgatum* was studied in the laboratory. Our results suggest that current population trends could potentially be due to minor differences in egg development and larval growth favouring *S. striolatum* in most years under the current environmental conditions.

# 14 First insight into the DRAGON project: Dragonflies as bellwether for the human impact on European wetlands

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**Keywords:** citizen science, biodiversity monitoring, standardized and opportunistic data, human pressures, land-water interface

The ongoing biodiversity crisis urges scientists to provide comprehensive indicators of biodiversity changes and how they link to anthropogenic pressures. Temporal monitoring is the most effective tool to estimate population trends, assess impacts of anthropogenic change, design necessary protective measures and assess their efficiency. However, standardized data remain scarce and are generally limited to a few regions, ecosystems and taxa. Opportunistic data, on the other hand, are more widely available and cover many understudied groups such as insects. The DRAGON project aims to strengthen our understanding of the drivers of odonates' biodiversity change and provide tangible recommendations for mitigating human impacts by combining opportunistic and standardized datasets. This project will consolidate an international consortium of experts to work with stakeholders and develop new indicators of human pressures on odonates. These indicators will provide essential proxies to monitor wetlands and other aquatic-terrestrial interfaces or 'ecotones' (e.g. peatbogs, river banks, etc.), understand the threat to odonates and support better protection and restoration of their habitats. As a first step, we will map, collate, and harmonize existing datasets (standardized and opportunistic) of odonate records available in Europe. We will then review and expand the methods used to analyze such data to harness their full potential to produce reliable estimates of trends and enable multiscale analyses of odonate responses to environmental conditions and landscape contexts across Europe. We will integrate expert knowledge as well as information contained within the data to identify potential biases and where possible, control for their effects. Finally, we will operationalize indicators by linking these trends to human pressures on wetlands at the interface between terrestrial and freshwater ecosystems that represent a gap in our current biodiversity monitoring. These indicators will be fully accessible, interoperable and ready to be integrated into conservation tools at national and European scales (e.g., proposal for new SEBI biodiversity indicators).

# 15 Potential effects of climate change on distribution and ecological interactions in Odonata

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**Keywords:** climate change, distribution, Odonata, competition, predation

Human-influenced climate change has had major impacts on biodiversity, including Odonata. For a better understanding on how climate change affects the biodiversity of Odonata we need knowledge on: (1) Recent geographical distribution changes, (2) Model predictions on how future climate change affects distribution, (3) Experiments on how interactions between species are affected by changes in climate. I will provide examples from our current knowledge on these three points using European Odonata. I will also highlight topics and areas where more research is needed for a better understanding on the effects of climate change in Odonata.

# 16 Impacts of climate change on dragonflies and damselflies in West and Central Asia

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**Keywords:** climate change, Middle East, Central Asia, conservation, endemics

Based on 149,001 records, distribution models were created for 159 species using MaxEnt. Environmental variables consisted of climate variables taken from BIOCLIM, river data, and soil data. The Future climate data was obtained from CHELSA from CMIP6 climate models. The same variables were collected for three scenarios (SSP1-2.6, SSP3-7.0, and SSP5-8.5) of shared socioeconomic pathways for the years 2050-2070 and 2080-2100. For each scenario and time period diversity maps were prepared for six species groups: all species, lentic, lotic, Oriental, Afrotropical, and Palearctic species. Strong declines in diversity are expected in western Turkey, the Levant, and Azerbaijan, and to a lesser extent in parts of Iran and southern Central Asia. An increase is expected in eastern Turkey and at higher elevation in Central Asia with a limited increase throughout the Arabian Peninsula. In contrast to expectations a decrease in areas with low diversity (<15 species) was found. Faunal composition is predicted to show strong shifts, with Palearctic species declining and Oriental and Afrotropical species increasing. No clear difference between the trend of lentic and lotic species is found, although there are clear spatial differences in trend between these groups. None of the species are predicted to go extinct based on the impact of climate change only, however the combined impact of climate change and anthropogenic forces is likely to push some of the species to near extinction by 2100.

# 17 Climate change impact on damselfly-parasite interactions

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**Keywords**: global warming, host-pathogen interactions, extinction risk, diseases ecology, Odonata

Climate change is one of the major causes of biodiversity loss. Insects are particularly vulnerable to climate change because of their short life span, ectothermic nature and dependencies on diverse habitats and other organisms. One way in which climate change can cause or contribute to extinction is by facilitating the spread of diseases and modifying host-pathogen interactions in a way that is detrimental to hosts. Therefore, understanding how climate impacts host-pathogen interactions is crucial. Here, we studied seasonal and latitudinal variation of parasitism in damselflies to determine how climatic factors impacts host-parasites interactions. We studied seasonal variation of parasite prevalence (i.e. the proportion of damselflies parasitised), and parasite intensity (i.e., the number of parasites per infected damselfly) in Bangladesh using *Agriocnemis femina* as a study system. We found a correlation between rainfall and parasitism; parasite prevalence and intensity are higher in dry seasons and lower in wet seasons. Furthermore, we determined parasite prevalence, parasite intensity from 32 sites across a 3000 km latitudinal cline in the eastern coast of Australia using *Ischnura heterosticta* as a study system. We found that parasite prevalence and intensity vary in different seasons. Our study further showed that parasitism varies across latitudes. We showed that parasite prevalence and intensity are higher at higher latitudes and lower at lower latitudes. We found a positive correlation between temperature and parasitism across latitudes. Our study provides evidence that host-parasitism varies across latitudes and in different seasons, and climatic factor such as temperature and rainfall are most likely drivers of the observed variation. Temperature and rainfall possibly cause variation of parasitism by impacting damselflies immune system and modifying concentration of parasites in the habitat. Our study suggests that parasitism is most likely to increase due to global warming, which will decrease insects' fitness and contribute to global insect decline.

# 18 Evolutionary history and divergence times of Odonata (dragonflies and damselflies) revealed through transcriptomics

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**Keywords:** molecular phylogenetics, fossils, systematics, Gomphidae, Petaluridae

Dragonflies and damselflies are among the earliest flying insects with extant representatives. However, unraveling details of their long evolutionary history, such as egg laying (oviposition) strategies, is impeded by unresolved phylogenetic relationships, particularly in damselflies. Here we present a transcriptome-based phylogenetic reconstruction of Odonata, analyzing 2,980 protein-coding genes in 105 species representing nearly all the order's families. All damselfly and most dragonfly families are recovered as monophyletic. Our data suggest a sister relationship between dragonfly families of Gomphidae and Petaluridae. According to our divergence time estimates, both crown-Zygoptera and -Anisoptera arose during the late Triassic. Egg-laying with a reduced ovipositor apparently evolved in dragonflies during the late Jurassic/early Cretaceous. Lastly, we also test the impact of fossil choice and placement, particularly, of the extinct fossil species, †*Triassolestodes asiaticus*, and †*Proterogomphus renateae* on divergence time estimates. We find placement of †*Proterogomphus renateae* to be much more impactful than †*Triassolestodes asiaticus*.

# 19 Bivoltinism in the univoltine *Lestes sponsa*? Possible effect of water management and climate change

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**Keywords:** life history, larval development, over wintering, diapause, bet hedging

Odonates of the temperate zone have developed strategies for overwintering. Lestid species are univoltine, mostly overwintering as eggs in an early and/or advanced development stage, rarely as larvae or adults. The Euroasian *Lestes sponsa* overwinters in the advanced egg stage, but hatching before overwintering has been observed in laboratory conditions. The timing of its emergence is plastic depending on latitude and the species may show a long pre-reproductive period and hence a long adult lifespan. Yet, in Southern France, *L. sponsa* mainly flies from May to September, with the flying period of coastal populations peaking in May, and that of mountain populations peaking in August. In a temporary coastal marsh which is artificially flooded in August (i.e. before the natural flooding season), a pair of *L. sponsa* was observed on 17 October 2017 (i.e. well after its usual flying period) suggesting the emergence of a second generation.

To assess the likelihood of this hypothesis, we sampled eggs laid during June in plant shoots and filter papers, and put them in water in August. From eggs laid in shoots, 7.9% hatched in autumn. Among eggs that hatched from filter papers, 24.7% did so in autumn and 75.3 in the next spring. We reared larvae from these two cohorts (autumn and spring) in a climatizer mimicking natural temperature and photoperiod. Larvae of the autumn cohort emerged from mid-September which was congruent with the field observation, showing the likelihood of bivoltinism. Due to higher temperatures than in spring, larvae of the autumn cohort developed faster, but emerged as smaller adults with heavier mass, and therefore higher wing loading. This could decrease adult flight and hunting performances, especially with harsher weather than in spring. Future milder autumn conditions due to climate change may enhance the occurrence of a second generation in *L. sponsa*.

# 20 Conservation of the threatened *Lestes macrostigma*: from detailed ecology to habitat management and restoration

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**Keywords:** evidence-based conservation, larval ecology, oviposition plant, salinity, genetic pattern

*Lestes macrostigma* is threatened and in need of conservation efforts. Although its restriction in Europe to vernal brackish waters is long known, knowledge of its detailed ecology was lacking to implement evidence-based conservation. Hence, a study program was launched, combining laboratory experiments, field studies and pilot restoration actions. Key findings are:

- Adults favour the *Bolboschoenus maritimus* during oviposition and this plant provides higher egg survival.
- Higher salinity levels decrease larval survival and physiological performance, these negative effects bridging to adult stage.
- While flooding of ponds in autumn *vs* winter increases egg survival, flooding in summer *vs* autumn increases the abundance of larger predating aeshnid larvae, which decreases the larval abundance of *L. macrostigma* in the next spring.
- Later flooding during emergence allows a higher number of larvae to achieve their development.
- Larval abundance is higher in smaller ponds, suggesting that these are favoured by adults during oviposition site selection.
- Adults tend to be bigger when they emerge from deeper ponds, likely because of lower temperature leading to lower growth rate and longer development.
- The species falls into three distinct genetic groups that follow cold, temperate and arid climates based on Köppen-Geiger (i.e. temperatures and precipitations) classification.

Hence, to favour *L. macrostigma* during habitat management and restoration, we recommend: (1) that flooding of temporary ponds should not happen before November and last until June; (2) that water salinity levels should not exceed 4–6 g/L at the time of hatching in March and 10–12 g/L at the time of emergence in May; (3) to favour colonisation by *B. maritimus* possibly through active restoration by sowing seeds and transfer roots; (4) to increase habitat availability by digging ponds of small size (200–1,000 $m^2$) but higher depth (80–120 cm); (5) to sample eggs within the same genetic group in case of reintroduction projects.

# 21 Climate stability is a key driver of difference in the global richness of lentic and lotic odonates

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**Keywords**: freshwater organisms, habitat affiliation, habitat-stability-dispersal hypothesis, lentic and lotic habitats, Paleoclimatic stability

Freshwaters cover less than 1% of the Earth's surface but harbor ~10% of all described species. According to the habitat-stability-dispersal hypothesis, the classification into lentic and lotic species reflects several important adaptations to the spatial and temporal stability of their habitat. However, evidence for this hypothesis remains limited to temperate regions and the environmental drivers of the distribution of lentic versus lotic species are unexplored. Using uniquely comprehensive distributional and habitat data for 56% of odonate species together with proxies for contemporary climatic conditions as well as paleoclimatic stability, we provide the first global assessment of the drivers of lenticity (lentic to lotic ratio) for any freshwater taxon. Single regressions show that temperature is the most important driver of lenticity, with high lenticity both in very warm and very cold conditions. Multiple regressions reveal that temperature is just a surrogate for multiple predictors of the stability of contemporary and paleoclimatic conditions. The main pattern in lenticity of assemblages ($R^2$= 0.86) follows a gradient of increasing lenticity with decreasing stability. Geographically weighted regressions highlight that productivity and seasonality explain the higher lenticity in regions with more extreme climatic conditions (e.g. desert etc.) and emphasize the importance of paleoclimatic stability for species' distribution in regions that were glaciated during the last glacial maximum. The low importance of annual climate and elevation relative to stability predictors suggests a globally minor role of habitat availability. Together with findings that lentic lineages of odonates are younger and more species rich in temperate regions, our results provide support for the general impact of habitat stability on the contemporary distribution of freshwater organisms. Moreover, the greater capacity of lentic species to respond to climatic changes, compared to lotic species, will broadly impact the composition of freshwater assemblages under global warming.

## 22 A theory of island odonatography

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**Keywords**: islands, Odonata, review, threats, research opportunities

For odonates, islands offer opportunities and limitations. On the one hand, there is the limited population size, the limited range, the high risk of extinction and the strong impact of habitat destruction and invasive species under island conditions. On the other hand, islands offer good opportunities for radiation and speciation. Secondly, islands may be resorts for endemics or act as stepping stones for invaders, especially under climate change conditions. The third perspective is that islands may serve as good models for trends in population size, habitat use, threats and extinction risks, worldwide. Because of isolation and clearly defined land size, it is easier to gain complete data sets, especially in the tropics.

# 23 Transcriptomics reveals high phenotypic plasticity of *Coenagrion puella* to experimentally induced temperature changes

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**Keywords:** climate change, phenotypic plasticity, species vulnerability, thermal responses, warming

Understanding how populations respond to changing environmental conditions at local and regional scales is critical for inferring their persistence under ongoing global change. Transcriptomic analyses are suited to identify genes potentially related to biological responses to environmental change. Here, we assess the phenotypic plasticity to temperature changes of *Coenagrion puella* (Coenagrionidae, Odonata) facing climate warming. Thus, we (1) assembled a *de novo* transcriptome of *C. puella* (94,435 genes); (2) performed heat shock experiments at three temperatures: "Cold" (4ºC), "Hot" (22ºC) and control (13ºC) across 24 individuals from warm (305 masl) and cold (1615 masl) populations; and (3) determined genes differentially expressed among treatments and their functional annotation. Our results show that the total number of differentially expressed genes decreased from "Cold vs Hot" (385 genes) to "Cold vs Control" (244 genes) and "Hot vs Control" (127 genes), with few genes overlapping across treatments, which suggests more complex responses to regulate gene expression in cold than hot conditions. Of them, 377 genes were functionally annotated, the majority associated to biological processes (regulation of cellular and metabolic processes, RNA polyadenylation, and response to stimulus). The response was similar for the warm and cold populations, likely due to common mechanisms, and supports high phenotypic plasticity for *C. puella*. Overall, although our experiment reveals *C. puella* is potentially able to tolerate climate warming, global change may affect this species by habitat loss if the pools that it inhabits dry out during extreme hot events.

# 24 Ordinal level phylogenomics of Odonata based on anchored hybrid enrichment

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**Keywords**: Odonata, phylogeny, genomics, systematics

Odonata comprise approximately 6400 species with extensive morphological and ecological diversity, specifically their colour variation, flight behaviour patterns, and breadth of ecological niches. Additionally, their phylogenetic placement within Insecta as descendants of the first winged insects make them ideal candidates for exploring evolutionary forces that have shaped diversity patterns (e.g., diversification rate shifts) as well as character evolution (e.g., flight behaviour, colour). Even though morphological and ecological traits are relatively well known for most odonate taxa, the lack of a well-supported phylogenetic hypothesis across Odonata have limited the capability of evaluating evolutionary phenomena in a comparative context. Previous studies using various taxon sampling schemes and data types (i.e., morphology, targeted locus approaches) to reconstruct odonate relationships failed to resolve several interfamilial relationships, specifically in groups with likely incomplete lineage sorting and/or introgression. Even though a recent study by Bybee *et al.* (2021) incorporated genomic-scale anchored hybrid enrichment (AHE) data for phylogenetic reconstruction, the relatively limited taxon sampling likely precluded resolution within the problematic groups. Our study, also targeting AHE loci, greatly expand taxon sampling to include at least one genus representative for approximately 95% of all odonate genera, which resulted in 729 newly generated samples in addition to 142 samples from Bybee et al. (2021) for a total of 831. With around 500 AHE loci, we aim to resolve historically difficult relationships and construct a robust ordinal phylogeny of Odonata, which will be used as the evolutionary framework to clarify taxonomic classifications and test evolutionary hypotheses regarding shifts in flight behaviours, colours, and diversification rates.

## 25 Mitochondrial DNA markers and their limitations in Odonata research

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**Keywords:** cytochrome c oxidase subunit 1, mitogenome, NUMTs, Odonata

Using mitochondrial markers to identify taxa and monitor biodiversity has limitations and risks. The transfer of DNA from mitochondria to the nucleus results in nonfunctional nuclear copies of mitochondrial DNA (NUMTs), which vary in abundance and size among different taxa. Thus, NUMTs can complicate molecular studies based on mitochondrial markers. The impact of this phenomenon in Odonata has not been studied much. We analysed the mitochondrial and nuclear genomes of *Leucorrhinia albifrons* and related species, including NUMT and cox1 sequences from *Leucorrhinia dubia*. Our findings show that NUMTs can significantly affect studies that use cox1 as a barcode for Odonata. We suggest using nad1 alone or in combination with cox1 to minimize confusion with NUMTs. Furthermore, we identified misidentified mitochondrial genomes in public databases. These results are essential for future metabarcoding and population studies of Odonata based on mitochondrial DNA markers.

# 26 Urbanization effects on life history traits in the damselfly *Ischnura elegans*

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**Keywords:** global warming, invasive alien species, phenotypic plasticity, seasonal time constraint, urbanization

Adaptation to urbanization may require ecological and evolutionary changes in response to anthropogenic factors such as "urban heat island' and invasive alien predators. Another natural factor - seasonal time constraint, which increases with latitude, may mediate the effects of these anthropogenic stressors. Here, we studied single and combined effects of increased temperatures and an invasive alien predator on the phenotypic response of replicated urban and rural populations of the damselfly *Ischnura elegans* and contrasted these between central and high latitude populations. Specifically, *I. elegans* larvae were exposed to current (20°C), mild warming (24°C), and heat wave (28°C for high latitude only) temperature treatments crossed with the presence or absence of the invasive alien spiny-cheek crayfish *Faxonius limosus*, only present at the central latitude. We measured larval life history traits: development time, mass, and growth rate. Urbanization type affected all damselfly traits, yet, these responses depended on latitude, temperature, and sex. Mild warming decreased mass in rural and increased growth rate in urban populations. The urbanization effect on mass was more pronounced in central-latitude populations. Urbanization effects were sex-specific with urban males being lighter and growing slower than rural males. At the current and mild warming temperature, spiny-cheek cues reduced the growth rate, independently of urbanization and latitude. However, predator effect reversed under a heat wave in high-latitude damselflies. The results underline the context-dependency of eco-evolutionary responses to urbanisation, and point that response to cities based on populations at a single latitude should not be generalized.

## 27 Timing and direction of faunal exchange between the Nearctic and Palaearctic in Odonata

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**Keywords**: Holarctic, dragonflies, damselflies, biogeography, dispersal

The biogeographic regions of the Nearctic and Palaearctic share some lineages of flora and fauna, and odonates are no exception. The Bering Land Bridge, which was restored during the Last Glacial Period, has been proposed to have served as both a dispersal route and a refugia. In this study, we reconstructed the phylogenetic relationships of 14 genera shared between Palaearctic and Nearctic using the mtDNA gene cox1 in order to investigate the lineage diversification and the faunal exchange between these regions. We applied a molecular clock to estimate the divergence times between Nearctic and Palaearctic species and investigated whether habitat (lentic vs lotic) predicts faunal exchange and distribution patterns. Our finding reveals the absence of a generalizable pattern of species divergence between the Nearctic and Palearctic regions, instead we found lineage-specific biogeographic patterns.

# 28 Distribution records of Javan endemic Odonata with notes on habitat characteristics for: *Heliogomphus drescheri* and *Rhinocypha heterostigma*

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**Keywords:** Odonata, Javan endemic, distribution

According to the Java Odonata Survey (Setiyono, 2014), 88 species of dragonflies and damselflies were recorded in Java during 2010 - 2014. The Indonesia Dragonfly Society (IDS) continues to conduct dragonfly research in Java in order to collect more comprehensive and updated data. Along with collecting species, IDS also conducted habitat study to provide support data for dragonfly conservation efforts in Java. IDS recorded 112 species in the most recent Java dragonfly data, from 2015 to 2023. There are 24 endemic species: 9 species (Java and Sumatra), 2 species (Java and Bali), 1 species (Sumatra, Java, and Bali), and the other 12 are only endemic to Java. *Rhinagrion tricolor* and *Coeliccia lieftincki*, two Javan endemic species, are only found on one satellite, Nusakambangan Island. The majority of these endemic dragonflies inhabit freshwater ecosystems in primary forest. *Heliogomphus drescheri* and *Rhinocypha heterostigma* dwell in densely forested streams. Their optimal habitat is a forest stream with a canopy cover of 50-80%, low light intensity, and an air temperature of 25-28 degrees Celsius. Both could be found in Central Java's Petungkriyono rainforest, where elevations range from 400 to 900 m asl. *Heliogomphus drescheri*, is only found in the middle regions of Java Island at elevations ranging from 0 to 900 m asl. *Rhinocypha heterostigma*, on the other hand, is exclusively found in the middle to western regions of Java Island, at elevations ranging from 400 to 1500 m asl.

# 29 Northern shift of Odonata and decline of Mediterranean river species in Spain and Portugal

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**Keywords:** Iberian peninsular, species trend, lotic community, national database, European Red List

Since the launch of the Grupo Ibérico de Odonatología in 2015, regional schemes and citizen science web portals active in Spain and Portugal are collaborating to build up an Iberian Odonata meta-database, containing 330,000 dragonfly records until late 2022, which is three times the records included in the 2015 European Atlas. Trends were calculated using the method of List-length, e.g. calculating for each species a binomial regression of the frequency of presence (% of positive 100 $km^2$ squares) in the period 2010-2020. The models were significant for 52 common species out of 77 taxa. Climate change conditions are matched, on one hand, by a strong increase of southern dragonflies paralleled with the decrease of temperate ones, and on the other hand, by severe stress on hydric resources and the current loss of Mediterranean sunny stream specialists (*Coenagrion caerulescens* and to a lesser extent, *Coenagrion mercuriale*, *Ischnura* sp.) and river species (*Oxygastra curtisii*, *Boyeria irene*, several Gomphidae). It was not possible to detect significant trends for rare and often threatened species because they are too much under-represented in the dataset and are scattered over the territory. Nevertheless, results suggest a decrease for *Macromia splendens* and *Gomphus graslinii*, two protected lotic species. Finally, the species *Aeshna juncea* is mostly restricted to mountain areas and seems to be also decreasing

in Spain. The trends of Iberian dragonflies can be compared within the context of Europe. For example, it is worth noting a decrease of *Coenagrion caerulescens* over its whole range. For South Western European endemic species, such as *Platycnemis acutipennis* and *Platycnemis latipes*, northward shift of their core distribution driven by global warming, results in a decrease in Iberia but an increase in France.

## 30 Of mice and men

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**Keywords:** dragonflies, beaver, excavation, impact, protection

The impact of water channel management and beaver presence on dragonfly communities was studied and compared at a protected site near the city of Trenčín (W Slovakia). The site´s name is Prepadlisko, situated in a highly urbanised, industrialised and farmed landscape. Since 1986 it has been protected as a nature reserve (NR) and since 2019 there is a national monitoring site (TML) for *Coenagrion ornatum* situated on a channel near the NR.

In autumn 2020**,** the watershed management body cleaned the channel, ending at approximately two-thirds of the TML, thus creating an opportunity to study its impact on the species and recolonisation after the event. At more or less the same time a beaver settled upstream on the channel. Its presence became evident mainly in 2022, when it cut off water influx both to the NR and TML.

Data show differences in the course and effect of the two studied ecological factors. The human interference was a one-off catastrophic event, which was self-repairing (dragonfly recolonisation and reconstitution of the assemblage) quite quickly. On the other hand, the beaver´s impact started very slowly and has been much more long-lasting. While the excavation was on the way to having a long-term positive effect on specialist species by creating favorable habitats, the beaver created in its pond conditions suitable for higher species diversity with a positive effect on generalists and neutral to negative on specialists. Downstream the beaver´s effect was detrimental, leading to drying out of the NR and TML in 2022 and local extinctions of dragonflies.

Therefore, a proper management seems to be necessary to maintain both beaver and specialist dragonfly species in this type of landscape.

## 31 Dragonflies on oceanic and sky islands face similar challenges

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Oceanic islands often have signature endemic odonates. This assumes that the islands have a deep history and are isolated from the mainland. The same can happen among odonates that live on sky islands that have experienced a long geologically stable history. Isolated oceanic and sky island area, topography, and moisture levels all play a role in determining local odonate assemblages. Here we compare oceanic island geology, topography, area, and climate of Indian Ocean islands with that of sky islands in the ancient Cape Fold Mountains at the southern tip of Africa in terms of their odonate faunas. We relate the findings to islands globally. Both oceanic and sky island odonates are experiencing great challenges in the face of direct human activity and climate change, not least because the highly adapted local species have nowhere else to go.

# 32 Historical Biogeography in the Neotropics an overview from the banner-winged and ruby-spot damselflies

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**Keywords:** Polythoridae, Calopterygidae, Hetaerina, Andes Coordillera, marine incursions

In this overview, we examine the biogeographical history of two damselfly families, the Hetaerininae subfamily of Calopterygidae and the Polythoridae family, in the Neotropics. We focus on the impact of important geological events in the region, such as the Central American Seaway (CAS) closure, the south American marine incursions, and the Andes uplift, on the diversification patterns of these two groups distributed across Central and South America. Both groups originated around the Eocene epoch, but Hetaerininae appears to have started diversifying during the Oligocene, while Polythoridae diversification began during the Miocene. Our results suggest that the Most Common Recent Ancestor (MCRA) for Hetaerininae damselflies may have originated in Central America. We tested two different scenarios of the influence of the CAS closure and found that our data supports a gradual closure of the seaway, which began in the Oligocene and ended in the Pliocene. The Pebas and Acre systems were identified as significant geological events associated with the early diversification of the Polythoridae family, while the rise of different Andean ranges had mixed evidence for its influence on diversification. The findings of our study contribute to a better understanding of the relationship between morphology, biogeography, and habitat in damselflies in the Neotropical region. Our results highlight the importance of considering the impact of significant geological events in studying the biogeographical history of these species. The diversification patterns of Hetaerininae and Polythoridae were influenced by different geological events, indicating that the evolutionary history of each family may be unique. By investigating the biogeography of these damselfly families, we can gain valuable insights into the historical processes that have shaped the Neotropical region and its diverse fauna. Overall, our study emphasizes the need for more research on the biogeography of arthropods in this region.

# 33 Disentangling the evolution of the metabolic allometry in dragonflies and damselflies (Odonata)

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**Keywords:** standard metabolic rate (SMR), genome size, cell size, surface-area-to-volume-ratio, phylogenetic comparative methods

Energy is a limited resource and its allocation is a strong selection factor for all organisms, with a trade-off between self-maintenance, growth, reproduction and survival. The energy expenditure of an inactive animal is defined as standard metabolic rate (SMR). The SMR varies widely among animals and scales with body mass – a relationship called metabolic allometry. Previous studies have found an exponential, positive relationship between SMR and body mass M ($SMR = M^b$), with a scaling exponent b usually between 2/3 and 3/4 (smaller animals have larger metabolic rates compared to larger animals, when accounting for their body weight). However, the exponential scaling for each taxon is unequivocal and the mechanisms driving this large observed variation in the underlying scaling exponent are still enigmatic. Furthermore, metabolic allometry has been mostly investigated in birds and mammals, leaving ectotherms such as the ancient insect order Odonata (dragonflies and damselflies) unstudied.

Here, I present the first insights into the metabolic allometry and its evolution across Odonata using different methodological approaches. My results show that the metabolic scaling exponent is drastically different from the expected 2/3 or 3/4 law reported from other animals, and that the intraspecific exponents vary substantially across the order. To disentangle the mechanisms driving this deviation in metabolic allometry, I use phylogenetic path analysis to characterize the direct and indirect effects of genome and cell size, body mass, wing length, surface-to-volume-ratio and thorax size on SMR. Finally, I model the evolution of SMR and other body traits using phylogenetic comparative methods and found evidence for a significant constraining force acting on all body traits. Surprisingly, I found evidence for evolutionary optima for behavioral flying modes (perchers versus fliers) but not for suborders. This suggests that the evolution of SMR and other body traits is closely linked to behavior in Odonata.

# 34 Sum or mean? Calculation problem of the Dragonfly Biotic Index, and a novel R package for its solution

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**Keywords:** Dragonfly Biotic Index (DBI); freshwater health assessment; aquatic macroinvertebrate; conservation prioritization, qualitative scoring methods

Dragonfly Biotic Index (DBI) has become an increasingly popular tool for assessing habitat quality, measuring restoration success, or conservation prioritisation. Each odonate species within a community is assigned a score ranging from 0 (widespread habitat generalists) to 9 (sensitive specialists). A total score is calculated as the sum of the scores of all species ($DBI_{sum}$) or as the sum of the scores divided by species richness ($DBI_{mean}$). Depending on input values, $DBI_{sum}$ may favor species-rich communities of generalists over smaller, more valuable communities, whereas $DBI_{mean}$ disadvantages communities of high-scoring species supplemented with many generalists. Despite these shortcomings, there has been only little criticism of either approach, and both have been used interchangeably. Using a set of the Czech odonate species along with simulated scenarios (high vs low richness, combined with the presence or absence of high- or low-scoring species), we tested the limits of $DBI_{sum}$ and $DBI_{mean}$, and suggested an optimization for a total score calculation. We worked under the presumption that each community can be assembled within certain maximum and minimum DBI values, between which the density of possible scenarios is not uniform. Permutation, showing the percentile of a community compared to a set of randomly assembled communities of the same species richness, appears to be the best solution. It is robust to the sampling effort and makes the calculation independent of whether $DBI_{sum}$ or $DBI_{mean}$ is used as input value. We also developed the 'dragDBI' package for R statistical software, a new tool for optimized DBI-based environmental health assessments. The presented solution is applicable to other macroinvertebrate-based qualitative scoring methods, such as the Biological Monitoring Working Party (BMWP) and the Average Score Per Taxon (ASPT). Our algorithm, along with the functions created within the 'dragDBI' package, will allow future additions of parallel solutions for other qualitative scoring systems.

# 35 Monitoring the dragonflies and damselflies of Cyprus

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**Keywords**: citizen science, checklist, distribution, climate change impact, flight season

The Cyprus Dragonfly Study Group (CDSG) started dragonfly recording at the beginning of 2013, monitoring just over 50 sites island-wide. With severe COVID travel restrictions in Cyprus in 2020, it was decided to do a detailed analysis of the results of the seven years of monitoring up to the end of 2019, which was published in *Diversity* in 2021. With 7877 site visits to 703 sites island-wide resulting in 23,899 records, this will provide a solid bench mark against which future trends – both locally and globally - can be established – a first for Cyprus and the eastern Mediterranean in general.

In 2020 there were 38 species on the island's checklist, but *Calopteryx virgo* was removed since its single sighting in 1930 was considered a misidentification. During the seven years of monitoring, three species were not recorded and for a further two, there were less than 4 records. *Aeshna isoceles* was only recorded in 2019 so data on this species is limited. For the remaining 31 species we have very robust and caveat-free data.

With its location at the crossroads of Europe, Asia and the Middle East, and Africa, Cyprus has an interesting mix of species from all three continents, with Cyprus being at the southern range extremity of species that have a mainly European distribution; at the northern range extremity of species with a mainly African distribution and north-western extremity of species with a mainly Oriental distribution. The impact of climate change is very obvious with increases in abundance and distribution where Cyprus is at northern extremity of the range such as *Trithemis arteriosa*, *Orthetrum chrysostigma* and *Orthetrum sabina*.

Although diversity of species on islands is normally impoverished compared with the neighbouring mainland, islands are noted for high levels of endemism. Although this is the case with many orders on Cyprus, the Odonata order is noted for an absence of any endemics.

# 36 Annual patterns of emergence and population sizes in Gomphidae: an overview

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**Keywords:** emergence, monitoring, global overview, *Gomphus vulgatissimus*

The prospect of being able to collect all exuviae left by dragonflies emerging from a habitat offers a suitable tool for quantifying the seasonal pattern of emergence as well as gaining data on population sizes that are often difficult to evaluate with other methods. It has often been observed that some gomphids perform mass-emergence from their riverine and large lake habitats and for gomphids exuviae collection it is often a standard method in surveys.

We present a biogeographical overview compiling studies on full seasonal patterns of emergence. In the first part we will give an overview from which regions emergence of gomphids has been monitored, for how many years monitoring data are available, which taxa are recorded and how good is the data base to make further analyses, e.g. about seasonal variations between regions or effects of climate change. We will also reflect on population sizes. In a second part, we will present some first analyses on the seasonality and population size based on data of *Gomphus vulgatissimus*, which may be the one odonate species for which most data on annual emergence, geographically and temporally, are available.

# 37 To hunt or to hide - effects of chemical cannibalistic cues on individual behavior – *Ischnura elegans* as a model

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**Keywords:** cannibalism, damselflies, behavioral ecology, respiration, chemical cues

Cannibalism is a common phenomenon observed in odonates larvae, which can significantly impact their fitness. The ability to recognize the presence of other cannibals may provide individuals with additional benefits, such as the opportunity to prepare for hunting or defense. This recognition could occur through individuals perceiving conspecific chemical cues. However, the role of conspecific chemical cues in cannibalistic interactions is less studied compared to interspecific predation. It remains unclear whether these cues inform odonates of danger or about food availability. Suitable interpretations by individual of conspecific chemical cues are crucial to balance the trade-off costs and benefits associated with anti-predator and feeding strategies, which could have a direct influence on individual fitness, the functioning of the trophic network, or even the entire ecosystem.

We conducted behavioral and respiratory experiments with larvae of the damselfly *Ischnura elegans* to investigate their response to conspecific chemical cues. We aimed to test whether larvae change their behavioral strategy to become bolder and more exploratory (cannibal strategy) or become more careful to avoid potential cannibals (prey strategy), whether they change their oxygen consumption patterns, and whether the strength of individual reaction to conspecific chemical cues depended on their concentration.

The results indicate that in response to conspecific chemical cues, *I. elegans* larvae decrease their activity levels and exhibit a shift in respiratory-related behavior, indicating the activation of antipredator (anticannibal) defense mechanisms. The strength of this response is proportional to the concentration of the cues. Our findings suggest that for *I. elegans* larvae, conspecific chemical cues convey information about danger rather than food availability. The choice of behavioral strategy by individuals seems to account for the level of danger, balancing the need to catch prey with the need to stay safe.

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# 38 Population abundance and structure of dragonflies: does the concentration of nitrates and orthophosphates matter?

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**Keywords:** peat excavations, alkaline fens, nutrients, Poland, Central-Eastern Europe

When fens are threatened because of climatic changes and anthropopression, there may be a man-made solution that supports dragonfly diversity. Peat excavations, water bodies after the extraction of peat, can become refuges for dragonflies. To create a model of an ideal peat excavation, some important factors should be discussed. Usually, such parameters are taken into account: water pH, its temperature, electrolytic conductivity, oxygen concentration. Measuring such parameters is relatively cheap and practical; moreover, it has been proved that with the rise of conductivity, the diversity of dragonfly species is lower. More detailed research based on detecting nutrients, involve using less practical photometers; measurements are more time-consuming with expensive reagents and calibrating the equipment regularly.

Preliminary research was carried out in the year 2002 in 15 peat excavations on carbonate fens in eastern Poland. Standard water parameters and concentration of orthophosphates and nitrates were measured six times a year. All the important information about the surroundings have been noted (close to the bank and further from the water body), spatial structure and morphometry of water bodies. Both larvae and imagines depend on temperature and pH. There is also a strong connection between the concentration of oxygen and imagines. Adult dragonflies choose water bodies with helophytes and the higher rush. Charophyta favour the diversity of dragonfly species. Moreover, tyrphophiles prefer water bodies in the mid and moderately late stage of succession. CCA analyses show that nutrients do not influence dragonfly assemblages directly. Nevertheless, in NMDS analyses one can see that sites are being grouped according to the concentration of orthophosphates which suggests that nutrients have indirect influence on odonatofauna, mainly by affecting the spatial structure of vegetation in the peat excavations.

# 39 Peat pools - a rescue wheel for aquatic fauna in drying peat lands, based on the example of dragonflies (Odonata)

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**Keywords:** calcareous fens, peat excavation, climate change

Calcareous fens in good condition occur in small areas of the EU. In Poland, the largest fen areas are located in central-eastern regions of the country. Most of the peat land areas are protected as nature reserves located in the vicinity of Chełm (51° 9'N, 23° 34'-23° 41'E). The site was surveyed for dragonflies in two periods when water was present at a significant number of sites (2007 – 2009) and when many sites were dry (2015 – 2018).

I conducted my research on four habitat types: a non-drained bog (TRF-N), a drained bog (TRF-Z), a channel (KAN) and a peat pool (TOR). A total of 50 dragonfly species (67.5% of the national fauna) were found from the two research periods: 41 spp. in 2007-2009 and 44 spp. in 2015-2018. It emerged that among the most significant factors shaping dragonfly assemblages and determining their survival in general is currently the drying out of habitats. Between periods the differences in species richness are almost imperceptible, however, the decline of species richness of particular posts was large. Important sites for the survival of the tyrphophilic fauna have become the hydrologically untransformed protected areas and the role of peat excavations as the refugia of the fauna.

Studies have shown that, with persistent climatic trends, the presence of peat pools or the continuity of habitats is important. In many cases they may be the only way to sustain a good condition for certain species and assemblages of dragonflies.

# 40 Modelling Past and Present Population Dynamics of the Black Petaltail Dragonfly

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**Keywords:** population genomics, Petaluridae, niche modelling, habitat specialist

Even though they are all habitat specialist, the individual species lineages within the family Petaluridae have persisted for tens of millions of years. It is not well understood how the Petaluridae have endured whilst living exclusively in fen habitats as nymphs. Methods to estimate the demographic history of individuals, populations and species have become more common in the past decade, but none have been used to model the history of petaltail dragonflies. Using a chromosome level genome assembly, resequencing data for over 200 individuals, and iNaturalist occurences we estimated current and historical demographics of the black petaltail dragonfly (*Tanypteryx hageni*) with Markovian coalescence analyses, site frequency analysis, and niche models. It is evident that present day population connectivity is not as high as niche models predict, suggesting that anthropogenic barriers could be hindering gene flow between populations. Interestingly, the micro chromosome shows no population structure, while the sex chromosome has two distinct clusters, each containing all but one population. This could be due to the presence of intriguing reproductive dynamics. By comparing historical models to long-term climate data, we found that the black petaltail has generally had a higher effective population size, and greater levels of gene flow between separate populations, in periods warmer than present day temperatures. Given the current dearth of gene flow, action may need to be taken to ensure the long-term survival of the black petaltail.

# 41 The X chromosome of insects predates the origin of Class Insecta

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**Keywords:** sex chromosome, genomics, phylogenetics

Sex chromosomes have evolved independently multiple times, but why some are conserved for more than 100 million years whereas others turnover rapidly remains an open question. Here, we examine the homology of X chromosomes across nine orders of insects, using the blue-tailed damselfly *Ischnura elegans* (Odonata) as our reference species, plus the outgroup springtails. We find that the X chromosome is shared amongst all insect orders examined and springtails, with the exception of the Z chromosome of Lepidoptera. Therefore, the insect X chromosome has persisted for more than 400 million years – the oldest known sex chromosome to date. Further, we suggest that the shrinking of gene content in the dipteran X chromosome has allowed for a burst of sex-chromosome turnover that is absent from other speciose insect orders. Finally, we show evidence that a region of the genome homologous to chromosome 2 in *I. elegans* appears to have been repeatedly incorporated into the sex chromosome through independent fusion events in distantly related insect taxa, suggesting it might be favourable for sex-linkage.

# 42 Ecology, behavior and speciation in *Mnais* damselflies

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**Keywords:** wing-colour polymorphism, alternative reproductive strategies, reproductive interference, mate recognition

*Mnais* is a widespread genus throughout East Asia and a recently speciated/speciating group among calopterygid damselflies. Males of each species are polymorphic but geographically variable. Two species (*M.costalis* and *M.pruinosa*) are endemic in Japan and they are sympatric in wide range of localities, and are allopatric in other places. Epidemiological studies conducted longer than 100 years by many odonatologists showed that, in either species, males of allopatric populations are polymorphic in their wing-colour (orange-winged and clear-winged males). By contrast, males of some sympatric populations were monomorphic (*M.costalis* is orange-winged and *M.pruinosa* is clear-winged). In some other sympatric populations, by contrast, males of both species showed wing-colour polymorphism, but interestingly they showed character release (*M.costalis* became larger and *M.pruinosa* smaller).

Male wing-colour is linked to alternative mating strategies (orange-winged males are territorial, while clear-winged males are non-territorial sneaks) in allopatry. However, the male wing-colour polymorphism is lost in sympatric areas due to reproductive character displacement: *M.costalis* males are monomorphically territorial orange-winged, while *M.pruinosa* males are monomorphically clear-winged including both territorial and sneak males. This loss of colour means a simplification of species signal and this functions to reduce heterospecific copulations and the production of hybrids. In other sympatric polymorphic populations, on the other hand, the character release is found to increase reproductive isolation.

In this talk, I will show some more ecological and behavioural traits, which may correlate with the local variation of wing-colour polymorphism and speciation. The traits may include habitat preference, thermal adaptation, operational sex ratio, mate choice, interspecific sperm competition, hybrid unviability, etc.

# 43 Indian dragonflies (Odonata) with special emphasis on the Doon Valley fauna and conservation

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Indian Dragonfly Society

**Keywords:** endemic, conservation, India

India is a highly dragonfly-rich country; over 500 species and subspecies (app. 10% of the world fauna), belonging to all the three Suborders (Zygoptera, Anisozygoptera and Anisoptera), occur in the country. While Kerala in southern India is among the odonatologically best studied states in the country (181 species, which is >36% of Indian fauna, including 68 endemics, belonging to 87 genera under 14 families of the two major suborders recorded till date), likewise, the world famous Doon Valley (29° 58' N and 31° 2' N lat. and 77° 34' E and 78° 18' E long., located in western ranges of the Garhwal Himalayan region at an elevation of 3,556 m) in Uttarakhand in north India is often regarded an unparalleled stronghold for a century-old dragonfly research history: > 90 species, which is app. 18% of all Indian species described. This included the newly described two endemic damselflies, namely, *Agriocnemis corbeti* Kumar & Prasad, 1978 and *Calicnemia doonensis* Sangal & Tyagi, 1984. Many of these taxa are either rare or endemic to the Valley, e.g. *Burmagomphus siwalikensis*. Almost 50% of the Doon Valley species have been investigated cytotaxonomically with haploid chromosome number range being n=12-14, and the average type number n=13. Gomphids like *Onychogomphus saundersi duaricus* Fraser is special to exhibit how chromosomal fusion, involving X-chromosome, results in lowering the chromosome number than the normal – a hypothesis Tyagi (1977) propounded for the karyophylogeny of Odonata. Several species of the Doon Valley are now threatened and need urgent attention for conservation, e.g., *Burmagomphus siwalikensis.* One of the major reasons for threat to their existence is the human interference or anthropisation. I have been continuously studying the Doon Valley dragonflies for their conservation during past 48 years.

# 44 Assessing and resolving relationships within family Macromiidae using targeted enrichment

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**Keywords:** phylogeny, AHE, taxonomy

Macromiidae is a family of North American, African, Asian, and European anisopterans consisting of 126 species, currently known to be divided into 4 genera. The monophyly and placement of this group have been debated in the past, leading to further contention towards the tip of the tree, among genera and species. Although this has been somewhat investigated in the past, comprehensive phylogenetic analyses examining the interesting dynamic present in this family have yet to be carried out.

Using Anchored Hybrid Enrichment (AHE), a targeted enrichment method, this study was focused on evaluating and assessing the monophyly of this group and the relationships within. More specifically, this study was also aimed at examining the intraordinal relationships among the different genera and species within this group, particularly focusing on the genus *Macromia* which is the most speciose of all four genera, and *Didymops* which by contrast, is the least speciose with just two species. Anecdotal observations and hypotheses suggest the possible splitting of the genus *Macromia* and the sinking of the genus *Didymops*, potentially resulting in a new genus. Using a ~20 and ~500 locus AHE probe set previously designed, *de novo* sequences which are used in the multiple sequence alignment are generated. After trimming, assembly, and partitioning, a Maximum Likelihood tree using IQ-Tree is constructed. We expect the results and topology of this tree to support the monophyletic status of the family. Additionally, we expect some clarity on the monophyly of the very speciose genus *Macromia* as well as some clarity on the position or sinking of the least speciose genus *Didymops.* Overall, in conjunction with some morphological data, we expect to provide a robust phylogeny fully resolving all contentions involving this group, and this could further help us answer interesting evolutionary questions within this group.

## 45 From records to conservation

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**Keywords**: EU, Habitat Directive, legislation, monitoring

The knowledge of the distribution and ecology of dragonflies is well developed in comparison to most insect groups, at least in Europe. Current EU-legislation, such as the Habitats Directive (HD) and Water Framework Directive (WFD), have helped the conservation of dragonflies in Europe but are not sufficient. Many aquatic habitats are not covered by the WFD and the dragonflies listed in the HD are not the species that need protection most urgently. In general, there is much more attention for conservation of terrestrial and marine habitats than for freshwater habitats. Within freshwater habitats large lakes and rivers get most attention while the small water bodies, that house a large part of the aquatic biodiversity including most dragonflies, are often neglected. We know that dragonflies can be valuable indicator species for these freshwater habitats.

There is increasing attention for the protection and monitoring of biodiversity at EU level. Therefore, now is the time to make sure that dragonflies and their habitats are incorporated in the programs that will be developed. This means we need to show that dragonflies are valuable as umbrella species, demonstrate that it is possible to use them as such and bring this to the attention of the right people. This is quite a task but also a great chance to help dragonflies and their habitat.

# 46 Novel hatching cue in the neotropical damselfly *Megaloprepus caerulatus*: larval adaptation and maternal constraint

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**Keywords:** embryonic development, cannibalism, shared nursery

The evolution of sibling cannibalism as a maternal strategy is particularly challenging to explain when nurseries are shared among multiple females. Such is the case for the damselfly, *Megaloprepus caerulatus*, whose females lay eggs in bark a few cm above the water-line in large, water-filled tree holes. Asynchronous egg hatch appears to be a maternal bet-hedging strategy to increase the chances that cannibalistic offspring hatch during 'windows of opportunity' which occur after the remaining large larvae emerge, having eaten all others. We investigated the proximate causes of asynchronous hatching. After collecting females before they oviposited at male territories, we allowed each to lay eggs into a moist filter paper, which was then held in a 50-ml water container in an outdoor insectary equipped with a min-max thermometer. Containers were checked daily for neonates, most of which hatched on or shortly after the first hatching day.

Egg hatch declined exponentially (maximum span of 181 days with decreased span in early dry season). Ambient temperature decreased with increasing rainfall. Treating fully developed eggs to a lower temperature for two hours triggered increased hatching relative to controls at ambient temperature. Subjecting neonates to displacement and drying experiments indicated that the low temperature hatching cue is adaptive. Neonates could not displace themselves more than 3 cm above the water line of partially submerged bark pieces, naturally moistened by capillary action. Only 40% of neonates in a 4-day drying treatment survived; none survived the 8- and 14-day treatments. Observation of egg clutches indicated that within a clutch, embryonic development was asynchronous, as evidenced by multiple developmental stages on any given check. The low-temperature hatching trigger we documented is novel among Odonata. It constrains a mother's control over offspring and increases competition among related and unrelated neonates for limited windows of opportunity in the shared nursery.

# 47 Diversity and distribution patterns of the dragonflies and damselflies of Suriname

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**Keywords:** Odonata, specimen collection, Naturalis, observations

Suriname is a South American country, situated on the Guiana Shield. In this country three geomorphologic areas can be discerned: the Coastal Plain, the Savanna Belt and the Interior with mostly tropical rainforest.

Naturalis Biodiversity Center in the Netherlands houses the largest collection of dragonflies and damselflies from Suriname in the world. The Surinam specimens were collected in the 20th and 21st century. The three persons, who gathered most, are all Dutch odonatologists: Dirk Geijskes, Jean Belle and Marcel Wasscher. Lodewijk Schmidt is a Surinamer who also made important contributions to this collection. The 19,000 records from the Naturalis specimen collection and the 5000 records from more recent observations open the possibility to map the distribution of Odonata in Suriname.

Recent observations have precise location information in the form of GPS coordinates. The information on localities of the collected specimens however is restricted to local names. These locality names were matched with coordinates, as far as possible, using different sources. We aggregated the Odonata records in grid cells of 50 by 50 kilometers and produced distribution maps for all 312 dragonfly and damselfly species of Suriname for two periods, before 1975 and from 1975 onwards.

The highest diversity of Odonata was found in the Savannah Belt. The grid cells in the surroundings of the capital Paramaribo have a high number of observations compared to other parts of the country and this is especially so for the period from 1975 onwards. We discuss the distribution patterns of several dragonfly and damselfly species in Suriname in more detail and address the limitations of the interpretation of the distribution patterns.

# 48 Environmental drivers shaping Odonata assemblages in a Ramsar declared floodplain wetland in South-Eastern Europe

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**Keywords:** diversity, aquatic macrophytes, physico-chemical water properties, anthropogenic pressure, protected habitats

Floodplains are heterogeneous systems adjacent to large rivers, periodically flooded by water originating from the river's lateral flow. During floods, the water spills into surrounding channels, ponds and lakes, creating an integrated dynamic system characterized by a mosaic of lotic and lentic habitats and by the exchange of nutrients and inhabiting organisms between the main river and its floodplain. Odonata nymphs were sampled from a total of 15 study sites in the Kopački rit wetland in Croatia, located in a floodplain of the Danube River. The study was conducted over a two-year period in each season using a benthos hand net. The main goals were: (1) to compare the Odonata assemblages from two main habitat types: near natural and anthropogenically impacted; and (2) to examine the effects of macrophyte vegetation and environmental variables on the spatial distribution of Odonata assemblages. A total of 20 Odonata species was recorded. Odonata assemblage metrics (species richness, diversity and abundance) were significantly higher at the anthropogenically impacted sites than at the near natural sites. This was mostly due to significantly higher macrophyte species richness, diversity and abundance at the same habitats. Together with higher macrophyte assemblage metrics, other environmental variables (e.g. nitrate concentration in water and water transparency) were included in shaping Odonata assemblages in a studied floodplain wetland. Our results indicate that anthropogenic modifications can enhance habitat heterogeneity through denser macrophyte development, which then supports more species rich Odonata assemblages. Some of the Odonata species documented are of national and/or international conservation concern, which confirms the conservation value of the habitats studied, and could contribute to the protection of endangered wetland ecosystems and their biota.

# 49 Phylogenomics, population structure and behaviour of *Neurocordulia*

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**Keywords:** Corduliidae, SNPs, phylogeny, flight, bats

*Neurocordulia* are commonly called shadowdragons due to their tendency, as crepuscular species, to fly at dusk. Here, we collected individuals from a population in Ontario, Canada, and sequenced SNPs, evaluating their population relationships while also attempting mark and recapture collection. We present here haplotype networks for *Neurocordulia yamaskanensis,* a phylogeny of the genus *Neurocordulia* based on AHE sequences, and a review of their flight behaviour.

# ABSTRACTS (POSTERS)

**ICO 2023**

**International Congress of Odonatology**

**25-30 June, 2023, Paphos, Cyprus**

# 50 Population monitoring of Brachythemis *leucosticta* in Nigerian French language Village, Badagry, Lagos Nigeria

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**Keywords:** recapture, upstream, seasonality, dragonflies, Libellulidae

This study assessed the population dynamics of *Brachythemis leucosticta* during the wet and dry season in the Nigerian French Language village, Badagry division, Lagos, Nigeria using the Capture-Mark-Recapture (C.M.R) method. Sampling was carried out three times a year for two years during dry and wet seasons in 2020 and 2021. Adults were captured at different parts of the streams (upstream, midstream, downstream) using sweep hand nets. They were marked on their wings with a permanent marker and released, with resampling carried out after two hours. Results showed that 324 individuals were captured through the entire study with only 120 recaptured. There was no difference in the population size of the insect during the dry season but the average number during the wet season was greater than that of the dry season though the difference appears non-significant. Further analysis showed that a higher number was dominant during the wet season: Shannon Diversity H' was greater in the dry season 0.7995 than the wet season 0.553. Only five marked individuals were recaptured upstream and midstream indicating a homogenous population. No marked individuals were captured downstream. However, the need for further studies on the biodiversity of these species and dragonflies in general is very important to prevent high reduction in the species' population.

# 51 Wings vs Genes: assessing the molecular phylogeny of *Euthore* Selys, 1869 damselflies

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**Keywords:** *Euthore*, damselflies, Colombia, phylogenetic reconstruction, color wing patterns

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The damselfly genus, *Euthore* Selys 1869, is exclusively distributed in the Andean mountain range of Venezuela, Colombia, Ecuador, and Peru, at elevations between 800 and 2600 m.asl. A previous morphological review for this colorful genus suggested that the genital ligula and male claspers are not good species diagnostic characters. Species' identification then relied exclusively on wing colour patterns, but this made delimitation of the *Euthore* damselflies unclear because of the heterogeneous nature of this characteristic. More recently, Sanchez *et al.* 2018 based on molecular phylogenetic reconstruction and genital ligula morphology, created the *Euthore* ***sensu latu*** which includes *Cora klenei* and *Cora lugubris.* In this study, we centered our effort on a molecular phylogenetic reconstruction using three mitochondrial (COI, 16S, ND1) and one nuclear (18S) fragment of the *Euthore* ***sensu stricto*** clade including five described morphospecies (*E. fassli Ris, 1914, E. hyalina (Selys, 1853), E. inlactea Calvert, 1909, E. leroii Ris, 1918,* and *E. mirabilis McLachlan, 1878*), four subspecies (*E. fasciata fasciata (Hagen in Selys,1853), E. fasciata fastigiata (Selys,1859). E. fasciata meridana Selys, 1879. E. fasciata plagiata Selys,1873*), and one form (*E. fasciata* form *sulfurata* De Marmels, 1982). Additionally, we evaluated wing color variation of males and females under the phylogenetic framework and described a new species for Colombia.

# 52 The genus *Sympetrum* Newman, 1833, how many species?

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**Keywords:** species delimitation, reproductive isolation, morphology, molecular markers

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The paper analyses/questions the taxonomic value of some morphological characters used in the systematic (species composition) of the genus *Sympetrum*, also, the species delimitation based on these characters. Faunistic research on *Sympetrum* species in SW Romania reveals that a set of morphological characters may either lead to a description of new species or that they are unstable characters with a low or no taxonomic value. Female specimens with black legs (and with males typical for *S. sanguineum*), and female specimens with predominantly yellow legs (typical for *S. meridionale*) have almost identical, bifid vulvar scales. The bifid vulvar scale of the black-leg specimens may or may not correspond with the intraspecific variability of *S. sanguineum* as reported by the literature. The bifid vulvar scale of the specimens with predominantly yellow legs is not typical for *S. meridionale*. Species delimitation based on morphological and molecular markers may be subjective. The paper proposes a holistic approach to species delimitation and their phylogenetic relationships: i) an integrative delimitation of species based on reproductive isolation (the biological concept of species), on morphology and geographical distribution and ii) molecular markers for phylogeographic patterns and phylogenetic relations. This approach raises many questions to be answered: Do (where, how, at what level) populations become isolated or do they represent a continuum (a spatial, behavioural continuum)?: what morphological and molecular distinct populations are – species, subspecies, species in statu nascendi?; are Odonata, as an old taxon, restricted from speciation and evolution?; is evolution with gene-flow possible in Odonata?

# 53 Nothing can go wrong when you love her: heterospecific mating in dragonflies

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**Keywords:** Odonata, dragonfly, interspecific mating, hybridization, mating behavior

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Dragonflies are a fascinating group of insects to study interspecific mating and hybridization due to their large size, conspicuous mating process, territorial behavior, and diverse mating systems. The study of these processes is important for understanding the evolution and behavior of species, as well as for conservation and protection purposes. This study focused on the genus *Sympetrum*, which has been previously reported to engage in interspecific mating. The research was carried out over two seasons (2021, 2022) at an artificial wetland in the Moravian-Silesian region of the Czech Republic, where at least five species of the genus *Sympetrum* were observed. During 23 days of field work, a total of 518 pairs were captured and identified. *Sympetrum striolatum* and *Sympetrum sanguineum* were the dominant species, accounting for 57.8% and 23.9% of the captured pairs, respectively. The proportion of interspecific pairs was 7.5%. The most common interspecific pairs were between a male *S. sanguineum* and a female *S. striolatum* and between a male *S. striolatum* and a female *S. vulgatum*. The study revealed that heterospecific mating in dragonflies is primarily influenced by species identity rather than season or weather, and the presence of another species counterpart is the main predictor of heterospecific mating. When possible, eggs from pairs of interspecies were taken, and the larvae of potential hybrid individuals are currently being reared for genetic analysis. Successful heterospecific mating occurs in closely related species, but pre-copulatory barriers are not strongly developed in some dragonfly groups, which may lead to interactions between less closely related species. This phenomenon must be studied, as it poses a threat to the survival of some species in the context of changing environmental conditions, including climate change.

# 54 Rearing and transport of Odonata larva

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For a description of an unknown exuvia of an Odonata species you need controlled exuviae. For travelling, you need small vials with an opening and a wooden stick inside. For transport of larvae, the vials should only contain a small amount of water. No feed should be included. The larva is sitting on the stick and mainly has the abdomen in the water. The larva can survive in this state for more than 36hr. During this time, it is only necessary to check for moisture within the vial.

After returning home, you should transfer the larva to the Aquaflorarium, where each larva should have its own container with some algae for aeration and a long stick for development. On the bottom some stones help to hide the larva. Additionally, a minimized aeration by a typical aquarium pump may be helpful for longer breeding. For feeding, mosquito larvae, similarly small insects and also frozen mosquito larvae are all suitable. These simple conditions are the best to have success with the development. If the adult emerges, the exuvia from this specimen should be numbered. So, the controlled exuvia can be stored and easy recognized later.

# 55 Conservation status of the threatened Dark Spreadwing *Lestes macrostigma* in Bulgaria

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**Keywords:** distribution, salinity, water management, site protection, European Commission LIFE program

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*Lestes macrostigma* is restricted in Europe to temporary brackish waters. This species is "Vulnerable" in Europe and has been proposed for inclusion in the Habitats Directive. In Bulgaria, where the species is "Critically Endangered", it was known to reproduce at three sites: Shablenska Tuzla Lake, Pomorie Lake and Poda Lagoon, which are within designated Special Areas of Conservation of EU Natura 2000 network. Yet, Pomorie Lake is the only site where *L. macrostigma* has been established for the last 15 years while observations after 2002 were lacking from Shablenska Tuzla and Poda.

LIFE19 BG/NAT/000804 "Conservation of Pomorie Lake coastal lagoon" project aims for the improvement of priority habitat 1150* Coastal lagoon. Its action D3 aims especially for the monitoring of dragonfly assemblages. Hence, the reproductive status and population size of *L. macrostigma* was assessed using teneral (i.e. emerging) adult counts along transects. Abundance was extrapolated to the entire sites and season using classes along an exponential scale (e.g. dozens, hundreds, thousands,…, hundreds of thousands individuals). This monitoring scheme, to be proposed to the National Biodiversity Monitoring System, was applied during surveys of several coastal SACs from 2021 to 2023 in order to assess the current global conservation status of the species in Bulgaria.

Surveys revealed that, over one complete flying season, *L. macrostigma* populations at Pomorie and Shablenska Tuzla consisted, respectively, of hundreds of thousands and dozens of thousands of individuals. Atanasovko Lake harboured hundreds of individuals. On other hand, *L. macrostigma* disappeared from Poda, likely due to a change of water management in 2010 targeting priority bird species. These results make Pomorie Lake and Shablenska Tuzla Lake key sites for the conservation of *L. macrostigma*in Bulgaria and Europe. Their future remains, however, uncertain as the municipalities in charge of their management may consider conflicting uses such as mass-tourism development.

# 56 Urbanization effects on life history traits in the damselfly *Ischnura elegans*

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**Keywords:** global warming, invasive alien species, phenotypic plasticity, seasonal time constraint, urbanization

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Adaptation to urbanization may require ecological and evolutionary changes in response to anthropogenic factors such as "urban heat island' and invasive alien predators. Another natural factor - seasonal time constraint, which increases with latitude, may mediate the effects of these anthropogenic stressors. Here, we studied single and combined effects of increased temperatures and invasive alien predator on the phenotypic response of replicated urban and rural populations of the damselfly *Ischnura elegans* and contrasted these between central and high latitude populations. Specifically, *I. elegans* larvae were exposed to current (20°C), mild warming (24°C), and heat wave (28°C for high latitude only) temperature treatments crossed with the presence or absence of the invasive alien spiny-cheek crayfish *Faxonius limosus*, only present at the central latitude. We measured larval life history traits: development time, mass, and growth rate. Urbanization type affected all damselfly traits, yet, these responses depended on latitude, temperature, and sex. Mild warming decreased mass in rural and increased growth rate in urban populations. The urbanization effect on mass was more pronounced in central-latitude populations. Urbanization effects were sex-specific with urban males being lighter and growing slower than rural males. At the current and mild warming temperature, spiny-cheek cues reduced the growth rate, independently of urbanization and latitude. However, predator effect reversed under a heat wave in high-latitude damselflies. The results underline the context-dependency of eco-evolutionary responses to urbanisation, and point that response to cities based on populations at a single latitude should not be generalized.

# 57 Evaluation of Odonata communities and freshwater biota condition using R tools

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**Keywords:** habitat quality, diversity, qualitative scoring methods, quantitative analysis, R library

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Odonate communities are commonly used as indicators of environmental condition for the purposes of conservation management, or for the assessment of environmental change over the long- and short-term. For assessing freshwater habitat condition, qualitative scoring methods are effective and popular tools. One of the widely applied methods is the characterization of Odonata communities by using the Dragonfly Biotic Index (DBI). However, no tool is currently available to automatically calculate the index. Moreover, for more comprehensive description of a particular assemblage, it is necessary to use quantitative analyses containing basic taxocoenosis parameters, e.g., indices of species richness or diversity. Among various online analytical tools (free or proprietary), R language and software has become increasingly popular. However, analyses in R software are often considered difficult and time-consuming for beginners. Therefore, we developed two R packages – 'dragDBI' (Calculation of Dragonfly Biotic Index for Odonata communities) and 'biodiva' (Biological Diversity Analysis) which offer a total of 23 user-friendly functions. The package 'dragDBI' provides several functions, including a new permutation-based algorithm that shows a percentile of a community compared to a set of randomly assembled communities of the same species richness, thus enabling rapid habitat ranking for conservation prioritization. The package also includes reference checklists with DBI values for Central European and South African odonate species. Moreover, it contains functions that can be used for data loading, quality checking (misspelling), and calculation of total DBI score for particular assemblage. The package 'biodiva' provides functions that deal mainly with species richness and abundance of samples, structural parameters as dominance and frequency, indices of species richness, diversity and evenness, and pair-wise similarity of samples. Both 'dragDBI' and 'biodiva' packages provide quick and user-friendly calculations and a graphic presentation of parameters, which may be extended in the future based on user requirements.

# 58 Dragonflies (Odonata) of Western Slovakia

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**Keywords:** Odonata, biodiversity, Western Slovakia, wetlands ecosystems, field research

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In the period 2016-2022, we carried out odonatological field research in three geomorphological units located in Western Slovakia - Borská nížina lowland, Little Carpathians and Danubian lowland. We collected faunal data from 140 sites, while 39,175 individuals within 52 species were determined. The aim of our work was to evaluate the current state of the odonata fauna of Western Slovakia (our research was carried out thanks to the support of the VEGA project no. 2/0011/21).

Individual species of dragonflies prefer different types of habitats for their development. The region of Western Slovakia is an extremely important area for the odonata fauna precisely because it provides dragonflies with diverse habitats on which their lifestyles depend, in the form of material pits, peat bogs, marshes, rivers, old river branches, water reservoirs, regulated lowland streams and canals and other wetland biotopes. The heterogeneity of the territory is one of the main reasons why up to 56 species of dragonflies are found here, which represents 80% of the species reported for the whole of Slovakia. Territorial protection in the form of a number of protected areas (including Sites of Community Importance) also has a significant impact. In the past, dragonflies were threatened here mainly by the loss of their habitats due to the massive drainage of wetlands. Nowadays, factors related to climate change (water warming, drying up of water bodies, succession) have added to this problem. It is therefore necessary to update data on the distribution and abundance of individual species, as many data are more than 20 years old. Based on these faunistic data, the threat status of the species can be reassessed and a new Red List of Slovakian dragonflies as well as a Slovakian Dragonfly Atlas created.

# 59 An Easy and Inexpensive Method of Detecting Polarization of Waterbodies and Its Application in Habitat Selection for Dragonflies

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**Keywords:** polarized light, analysis, Odonata, habitat selection, freshwater

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Horizontally polarized light reflected off of water surface is widely recognized as one of the main drivers in habitat selection for many freshwater-bound invertebrates, and dragonflies are no exception. Dragonflies rely on polarized light to locate suitable breeding habitats for their larvae. However, in the face of anthropogenic environmental changes, such adaptation has become compromised. Properties of attractive and suitable habitats, as well as ability to recognize them by polarized light reflected by water body of interest are mostly overlooked, yet important part of understanding dragonfly ecology. Therefore, understanding how dragonflies use polarized light to select their habitats is crucial for their conservation. Therefore, our aim was to identify differences in polarization between suitable and unsuitable habitats depending on substrate and vegetation and to design an easy and inexpensive method for measuring and analysing polarization of different waterbodies. These data were measured by a new analysing software for comparison, bringing a new approach to habitat selection study. With this tool, it was possible to recognize several key differences and attributes making attractive habitats from polarized light perspective. Our findings highlight the need for further research into polarized light perception in dragonflies and the potential benefits of applying this knowledge to habitat management and restoration efforts.

## Mid-congress field trip, Thursday 29 June

Cyprus is a water-stressed country and accessible dragonfly sites tend to be rather small. Consequently, we will be splitting the group up and using mini-buses, which will depart from Neapolis University at 08.30 on Thursday 29 June. Those of you not participating in the post-congress field trip will visit sites on the Diarizos river, ending up at the Arminou reservoir, which features the medieval Venetian Kelefos bridge, constructed between 1489 and 1571. There is an excellent chance of seeing the island's lotic species, including *Epallage fatime* (Odalisque), *Calopteryx splendens* (Banded Demoiselle), *Trithemis festiva* (Indigo Dropwing), *Orthetrum taeniolatum* (Small Skimmer) and *Onychogomphus forcipatus* (Small Pincertail). The Diarizos is also home to the island's speciality, *Ischnura intermedia* (Persian Bluetail). There will then be a late lunch at the Psilo Dendro ("Tall Tree") Trout Farm Restaurant, where there is a good chance of seeing the endemic Cyprus Jay. For those participating on the post congress field trip, visits will be made to sites on the Ezousa river below Episkopi and then on the upper Diarizos.

Above Diarizos river near the infamous Hassamboulia rocks and below Kelefos bridge

## Post-congress field trip, Saturday 1 to Monday 3 July

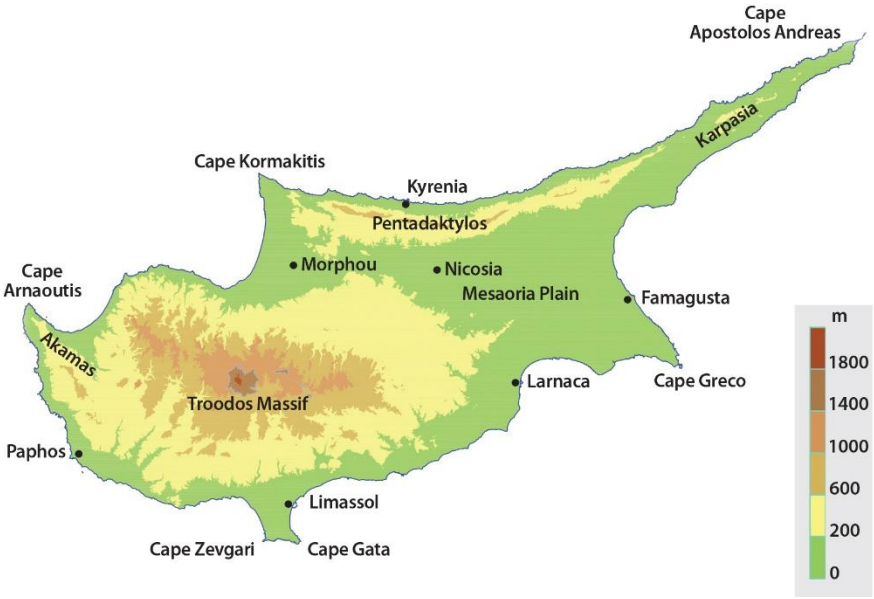
The three-day post congress field trip will depart each day from Neapolis University at 08.30. The first two days will be spent visiting sites on the lower and middle Diarizos river on one day, and on the other day the Akrotiri peninsula, agricultural tanks near Eptagoneia and the Gabion dam (which is currently the most species-rich site that we are monitoring). The third day will be spent at sites around the Paphos area where we will try to hunt down *Anax immaculifrons* (Magnificent Emperor), Europe's largest dragonfly.

Ezousa river below Episkopi

Gabion Dam

# Dragonflies and damselflies of Cyprus

## Geography and Climate of Cyprus




*Topography of Cyprus*

Cyprus is the third largest Mediterranean island with an area 9251 km$^2$ and lies at the eastern extremity of the Mediterranean basin. The island is characterised by two mountain ranges: the Troodos Massif and the Pentadaktylos ranges, separated by a broad east-west plain, the Mesaoria (translates from Greek to "between the mountains"). The Troodos Massif dominates the western part of the island reaching its highest point at Mount Olympus at 1951 m. asl., whilst the Pentadaktylos range is a narrow, unbroken ridge that runs for 160 km along the north coast.

Cyprus has an intense Mediterranean climate with hot (normally) rainless summers from mid-May to mid-September and generally mild and rainy winters from November to March. The island is water-stressed with an average rainfall of around 480 mm per year. There is, however, very wide local variation. The Troodos range has the highest rainfall (1100 mm per year), but this drops to as low as 300 to 350 mm per year to the east and on the Mesaoria

plain and parts of the island are classified as semi-arid. Rainfall on the Pentadaktylos range is around 500 mm per year but there are no significant rivers that flow off this range. The lotic species are therefore restricted to streams of the Troodos, particularly on the south and west slopes, making Paphos the best base on the island for dragonfly excursions.

**Monitoring of Odonates on Cyprus**

The study of dragonflies on Cyprus has a long history with publications dating back to the 19th century. In June 1994, Lopau and Adena made a one-month expedition to Cyprus and in 2002 published the first systematic study of the island's odonates. In this, all the literature was reviewed, collections in three museums catalogued, along with unpublished observations from visitors plus their own records from their 1994 visit. This resulted in 933 records and an updated checklist of 33 species. Between July 2003 and September 2004, FLINT (2019) carried out monitoring on the northern side of the island but the results of this were only published in 2019. This included the earliest observations of *Erythromma viridulum* (Small Red-eye) on the island. In August 2006, COTTLE (2007) recorded the first and only sighting of *Brachythemis impartita* (Northern Groundling) and also reported for the first *Trithemis arteriosa* (Red-veined Dropwing), although this species is now known to have been already present in 1999. In 2012 with these three additions, Cyprus' checklist stood at 36 species.

Recognising the lack of data on dragonflies, not only in Cyprus, but in the Eastern Mediterranean in general, the Cyprus Dragonfly Study Group (CDSG) was established with the aim of carrying systematic monitoring of odonates. Regular monitoring has been carried out at sites selected to include all the then known species and habitats and to give a comprehensive geographic coverage. The CDSG also seeks out new sites for monitoring and this has resulted in records from around 750 locations island-wide, 140 of which have been regularly monitored for a considerable (at least two years) time. An early success was the discovery of *Ischnura intermedia* (Persian Bluetail) in the Diarizos valley and since then at a total of 25 locations all in the south-west of the island (DE KNIJF *et al.* 2016). Then in 2019, there was the discovery of the previously unreported *Aeshna isoceles* (Green-eyed Hawker) in the Ronas valley on the Karpasia peninsula. Thus, in 2019 the checklist contained 38 species. However, for one species, *Calopteryx virgo* (Beautiful Demoiselle), there was just a single record reported by NAVAS (1932) who examined material collected by Mavromoustakis in 1930. There have been no further

sightings since then and seems unlikely that there are suitable cool streams with sufficient slow flow of water in the winter months to support the species. LOPAU & ADENA (2002) considered that this record was most likely a misidentification of a particularly blue specimen of *C. splendens* (Banded Demoiselle). This view was shared by the CDSG and SPARROW *et al.* (2021) recommended its removal from the checklist, which now contains 37 species.

The CDSG database now contains over 35,000 records and Cyprus is currently the most thoroughly investigated country in the region. This has allowed an excellent overview to be developed of the status, phenology and distribution of the island's odonates. Also the observations by Lopau and Adena from their expedition in June 1994 and the monitoring by FLINT (2019) in 2003 – 2004, although not as comprehensive, gives an good indication on how the distribution and abundance of species have changed over the last three decades.

Many of Cyprus' dragonflies have long flight seasons and dragonflies can be seen on the wing in every month of the year. As would be expected, the number of species on the wing and abundance does vary from month to month as shown in Figure 1. The number on species on the wing and number of records builds up rapidly from March, peaks from May to August and then slowly decline to the end of the year and into the following January.

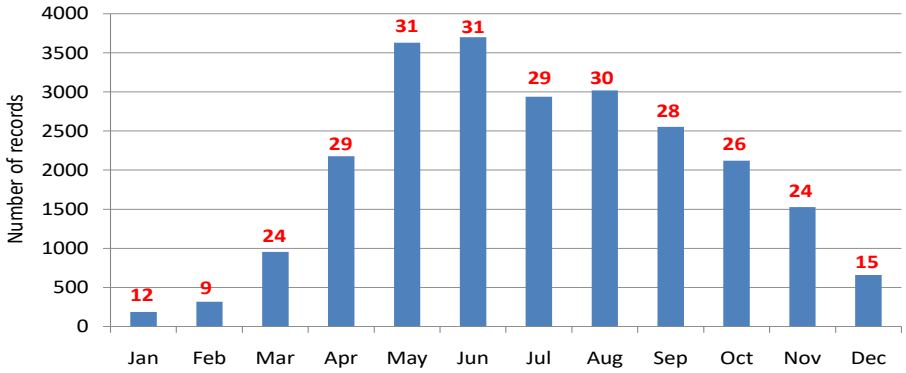



Figure 1. Number of records per month (blue bars) and the number of species recorded per month (red numerals) from the CDSG database for the period 2013 – 2019.

| | Family | Scientific name | Status |
|---|---|---|---|
| 1 | Lestidae | *Chalcolestes parvidens* | Rather scarce |
| 2 | | *Lestes barbarus* | Extremely rare |
| 3 | | *Lestes macrostigma* | Rather scarce |
| 4 | | *Sympecma fusca* | Common |
| 5 | Calopterygidae | *Calopteryx splendens* | Common |
| 6 | Euphaeidae | *Epallage fatime* | Common |
| 7 | Coenagrionidae | *Erythromma lindenii* | Rather scarce |
| 8 | | *Erythromma viridulum* | Rather scarce |
| 9 | | *Ischnura elegans* | Very common |
| 10 | | *Ischnura intermedia* | Rather scarce |
| 11 | | *Ischnura pumilio* | No longer present |
| 12 | Aeshnidae | *Aeshna affinis* | No longer present |
| 13 | | *Aeshna isosceles* | Extremely rare |
| 14 | | *Aeshna mixta* | Rather scarce |
| 15 | | *Anax ephippiger* | Common |
| 16 | | *Anax immaculifrons* | Scarce |
| 17 | | *Anax imperator* | Rather scarce |
| 18 | | *Anax parthenope* | Very common |
| 19 | | *Caliaeschna microstigma* | Rather scarce |
| 20 | Gomphidae | *Onychogomphus forcipatus* | Rather scarce |
| 21 | Libellulidae | *Brachythemis impartita* | No longer present |
| 22 | | *Crocothemis erythraea* | Very common |
| 23 | | *Diplacodes lefebvrii* | Rather scarce |
| 24 | | *Orthetrum brunneum* | Common |
| 25 | | *Orthetrum cancellatum* | Rather scarce |
| 26 | | *Orthetrum chrysostigma* | Very common |
| 27 | | *Orthetrum coerulescens* | Common |
| 28 | | *Orthetrum sabina* | Rather scarce |
| 29 | | *Orthetrum taeniolatum* | Rather scarce |
| 30 | | *Pantala flavescens* | Common |
| 31 | | *Selysiothemis nigra* | Rather scarce |
| 32 | | *Sympetrum fonscolombii* | Very common |
| 33 | | *Sympetrum meridionale* | Extremely rare |
| 34 | | *Sympetrum striolatum* | Very common |
| 35 | | *Trithemis annulata* | Very common |
| 36 | | *Trithemis arteriosa* | Very common |
| 37 | | *Trithemis festiva* | Rather scarce |

Table 1: The checklist of Odonata of Cyprus and the status of each species.

Although only a modest number of species, Cyprus, however, does have several charismatic species, in particular *Epallage fatime* (Odalisque), *Caliaeschna microstigma* (Eastern Spectre) and *Anax immaculifrons* (Magnificent Emperor) and is home to the island's speciality, *Ischnura intermedia* (Persian Bluetail). With its position at the crossroads of Europe, Asia and the Middle East, and Africa, Cyprus has a mix of species found in all three continents and in many cases is at geographical extremity of the species' range. For example, Cyprus is at the northern extremity of the ranges of the African species *Trithemis arteriosa* (Red-veined Dropwing) and *Orthetrum chrysostigma* (Epaulet Skimmer). Both of these species have dramatically increased their presence on the island in recent years, which is attributed to global warming. Furthermore, Cyprus is at the northwest extremity of the range of *Orthetrum sabina* (Slender Skimmer), *Orthetrum taeniolatum* (Small Slimmer) and *Trithemis festiva* (Indigo Dropwing). The thermophilic *O. sabina* which was previously confined to low levels and small populations has drastically increased its distribution range on Cyprus, occupying higher altitudes with significantly larger population sizes, again a consequence of global warming. On the other hand, Cyprus is at the southern extremity of the range of *Orthetrum cancellatum* (Black-tailed Skimmer). This species is particularly partial to open waters at cooler higher altitudes, and global warming may be a challenge for this species on Cyprus.

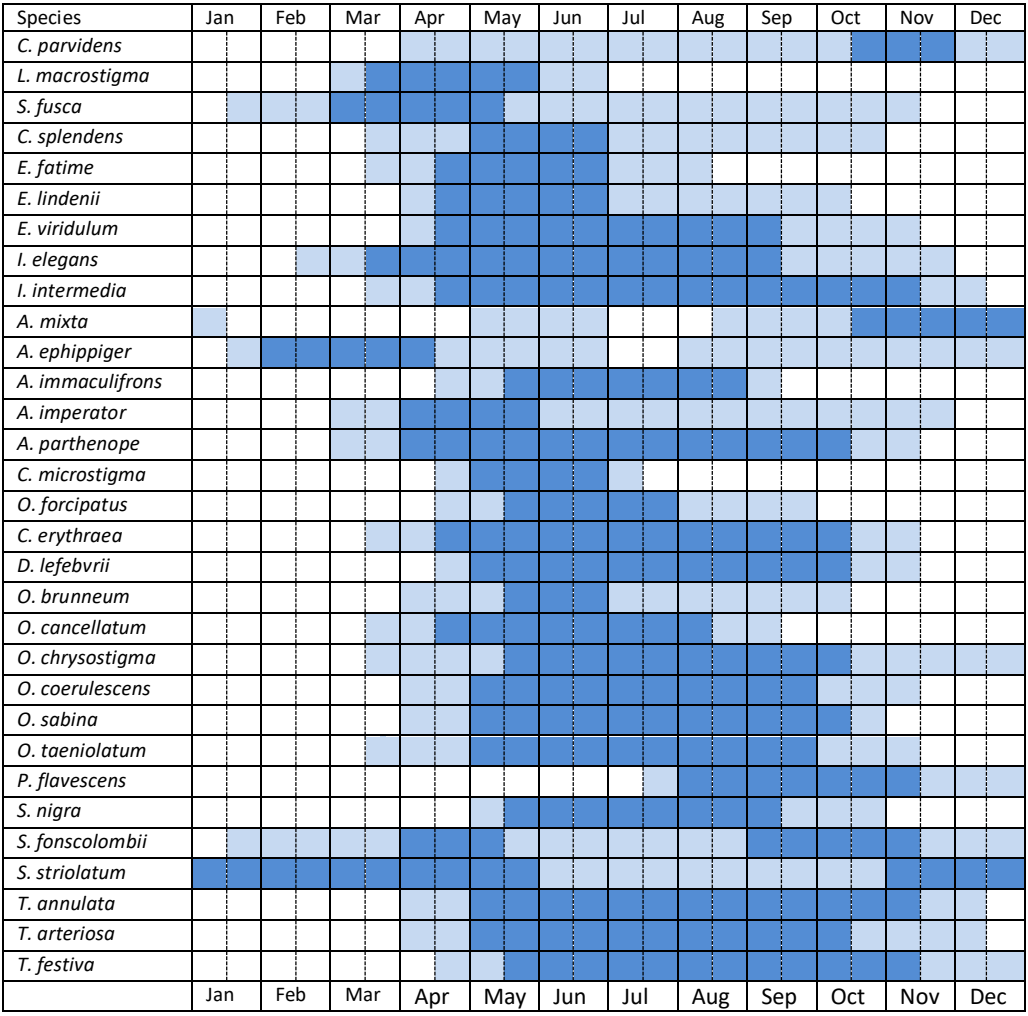



Figure 2. Flight Season and main flight season of the damselflies and dragonflies of Cyprus.

*Epallage fatime* (Odalisque): ♀

*Anax immaculifrons* (Magnificent Emperor): ♂

*Ischnura intermedia* (Persian Bluetail): ♂

*Ischnura intermedia* (Persian Bluetail): ♀ in the aurantiaca phase

*Trithemis arteriosa* (Red-veined Dropwing): ♂

*Orthetrum chrysostigma* (Epaulet Skimmer): ♂

*Orthetrum sabina* (Slender Skimmer): ♂

*Trithemis festiva* (Indigo Dropwing): ♂

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**International Congress of Odonatology**
**25-30 June, 2023, Paphos, Cyprus**

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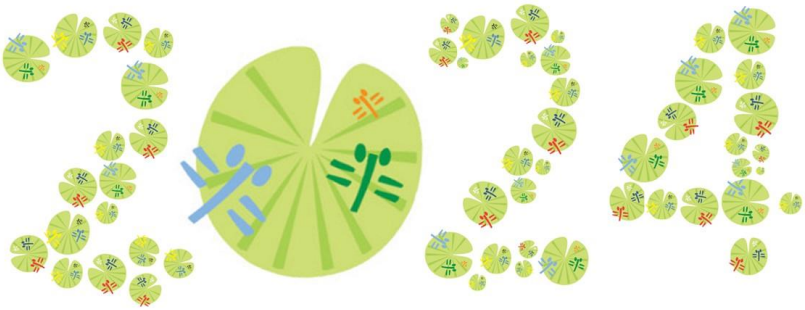
# ECOO 2024 Spain




ECOO 2024 • Spain • Andalusia
7th European Congress on Odonatology

ECOO 2024 will be held in the summer of 2024 in Andalusia, Spain.

# ICO2025 Colombia

I am delighted to extend an invitation to you for the International Congress of Odonatology 2025, which will take place in the beautiful country of Colombia! Known as the northwest gateway to South America and famous for its exquisite coffee, Colombia boasts an astonishing array of ecosystems and an unparalleled level of biodiversity.

Our country encompasses approximately 314 types of habitats, including unique high elevation ecosystems like the Paramo, a variety of tropical rainforests, savannahs, and even arid deserts. Within these diverse habitats, Colombia is home to a remarkable number of dragonfly and damselfly species. Currently, there are 480 known species, and by 2025, we anticipate that number to exceed 500!

The Pacific, Caribbean, Orinoco, and Amazon watersheds provide numerous suitable habitats that foster an incredible diversity of odonates. It is within this backdrop of natural wonders that the ICO 2025 will take place in the charming colonial town of Villa de Leyva, located in Boyacá. This town is conveniently situated just a three-hour drive from the vibrant capital city, Bogota D.C.

Villa de Leyva enjoys a pleasant climate, with average temperatures around 20°C or 70°F. However, it's important to note that weather variability in the Neotropics can be quite high, with freezing temperatures in the early morning, rising to the 20s°C during midday and dropping back to the low teens in the evening.

This touristic town is home to the largest cobbled square in South America, known as La Plaza Mayor, spanning approximately 14,000 square meters. For those with an interest in anthropology, a short distance west of Villa de Leyva lies an indigenous community named Muisca, which houses an astronomy observatory colloquially known as "El Infiernito."

Just around 15 km northeast of the town center, a stunning cloud forest emerges, creating the National Fauna and Flora Sanctuary Iguaque, accompanied by a group of seven waterfalls collectively called La Periquera. During the mid-congress tour, we will explore this sanctuary, allowing you to walk through the cloud forest all the way up to the Paramo. Prepare for some chilly high-elevation weather!

Furthermore, for paleontology enthusiasts, Villa de Leyva is situated in a fossil-rich valley from the Cretaceous era called the Paja Formation. One of the most

remarkable fossils discovered in 1977 is the Kronosaurus boyacensis, which is on display at the "El Fosil" Museum.

Additionally, the Biological Resources Institute Alexander von Humboldt has deposited its biological collections at the Claustro San Agustín, just a short distance from the Plaza Mayor in Villa de Leyva. We can arrange a visit to explore the insect, plant, bird, and egg collections gathered from our national preserved areas during some of the greatest expeditions.

Lastly, Villa de Leyva is renowned for its vibrant artistic and cultural festivals, including the Gastronomic and Wine Festival, Water Festival, Tree Festival, Jazz Festival, International Kite-flying Festival, and the Lights Festival. Rest assured, we guarantee a delightful culinary experience, including vegan options, along with craft beer, wine, and an abundance of cultural activities for the ICO 2025!

Our event will be hosted at either the Hotel Casa los Fundadores or the Hospederia y Centro de Convenciones el Duruelo, both of which are exceptionally beautiful convention centers. Additionally, there are numerous small hotels and even campsites available at affordable rates, catering to students and those on a budget. So, worry not, we have your accommodation needs covered!

We will announce the possible post-congress tours soon, but here is a unique opportunity to explore the other side of our country that for sure will take place. During your visit, you will journey to the Cordillera Occidental (West Tropical Andes) and explore the magnificent Parque Natural Nacional Tatamá. Here, you will encounter a completely distinct tropical rainforest teeming with a diverse community of odonates. Moreover, you can indulge in delightful morning coffee and experience the warm hospitality of the local people who will be your hosts.

We eagerly await the moment when you can immerse yourself in the wonders of one of the most extraordinary countries in South America, renowned for its exceptional biodiversity and cultural diversity.

Melissa Sanchez Herrera

**ICO 2023**
**International Congress of Odonatology**
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