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Odonata fauna of Khao Yai National Park and the adjacent regions in Thailand, Part II: updating information and citizen science

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Abstract

Larval and adult odonate surveys were conducted at 11 sites in Khao Yai National Park (KYNP) and adjacent areas during the rainy seasons (May–October) of 2023 and 2024, alongside a citizen science event in September 2023. A total of 106 Odonata species (61 Anisoptera, 45 Zygoptera) were recorded, increasing KYNP's known odonate fauna from 142 to 147 species. *Gomphidia kruegeri*, *Atratothemis reelsi*, *Copera chantaburii*, *Nannophyopsis clara*, and *Protosticta khaosoidaoensis* are new records for KYNP. *Epopthalmia vittata, Lestes decipiens,* and *Aciagrion paludense* were updated following recent taxonomic assessments, resulting in *A. paludense* documented for the first time in Thailand. Larval sampling, supported by the integration of citizen science data, yielded records of over 40 species, including nine for which the larval stage still awaits description. This study established an updated baseline for odonate biodiversity in KYNP, emphasized the importance of larval-stage documentation, and validated the efficacy of combining professional surveys with citizen science. Future research should incorporate molecular barcoding, seasonal resampling, and continued habitat-stratified surveys to monitor long-term biodiversity changes in response to climate variability.

Key words: dragonfly, damselfly, diversity, Khao Yai National Park, Thailand, larval records, citizen science, rainy-season, monsoon, biodiversity assessment

Introduction

In a previous and initial study conducted at Khao Yai National Park (KYNP) (Keetapithchayakul et al. 2023), field surveys were conducted in 2019 (January, April, May, and July), 2021 (February, March, April, and November), and in March 2022. Surveys could not be undertaken in 2020 and during the rainy season of 2021 due to COVID-19-related park closures. These surveys covered 26 sampling sites, focusing on both lotic and lentic habitats.

A total of 78 species were recorded, including 33 new records for the region, significantly increasing the known diversity from 109 to 142 species. The survey emphasized adult and larval collection, contributing valuable insights into the species' life cycles and habitat preferences.

However, a significant limitation of the earlier research was its lack of data collection during the rainy season. The timing of the rainy season in Northeast Thailand is influenced by both the onset of the southwest monsoon and observed patterns of rainfall accumulation. Therefore, the start and end of the rainy season may shift from year to year in accordance with variations in monsoonal activity and total precipitation, as recognized by the Thai Meteorological Department (Thai Meteorological Department 2025). Typically, the rainy season begins in mid-May, although in some years it may commence as late as early June. Rainy season conditions often create ideal environments for larval development and adult emergence, for example, many species belonging to families such as Lestidae, Libellulidae, and some Coenagrionidae are commonly found in temporary standing waters that form during the rainy season; most of these species must undergo diapause in the egg stage. These species typically complete their larval development in this period and emerge as adults during the late rainy season or early winter. Temporary aquatic habitats around KYNP usually diminish and dry up by November. Based on this pattern, the species composition of Odonata communities is expected to vary across seasons, particularly between the rainy and winter season. As the initial study focused primarily on the dry and cold seasons, without coverage of the rainy season, this created a significant gap in documenting seasonally distinct assemblages. As a result, the data from the initial study offer only a partial understanding of KYNP's Odonata diversity.

By addressing the gaps in previous studies, particularly the lack of rainy season data, this study aims to provide a more comprehensive understanding of Odonata biodiversity in KYNP. Utilizing both citizen science contributions and field surveys, we focus on offering insights into the larval stages, seasonal habitat, and overall species diversity. This approach seeks to fill critical knowledge gaps and contribute valuable data for future research and conservation efforts in the region.

Sampling sites

These sites were re-sampled from those surveyed by Keetapithchayakul et al. (2023: Table 1 and Figures 1–3). Fieldwork by the authors was conducted during the rainy seasons from May to October in 2023 and 2024, with sampling carried out on the following dates: 19–23 June 2023, 4–9 August 2023, 23–25 September 2023, 21–23 May 2024, and 9–11 October 2024. Sampling efforts focused on 11 sites (Table 1) within the boundaries of KYNP based on study of Keetapithchayakul et al. (2023), including selected adjacent areas (Figure 3C).

Heaw Suwat stream (S1; Fig. 1A–B) consists of a main channel and a smaller branch. The mainstream flows over exposed bedrock with intermittent patches of sand and mud, and is largely open to sunlight, with minimal canopy cover. In contrast, the branch stream is narrower and heavily shaded by overhanging trees, creating a distinct microclimate. Water flow is moderately fast in both branches. During the rainy season, the mainstream has a marked rise in water level compared to the hot and cold seasons, while the branch stream

Table 1. List of sampling sites from KYNP and adjacent regions (mixed water represents a habitat consisting of ponds and streams with slow current / (temporarily) dried up). * indicated the site located in KYNP

Code	Name	Location	habitats type
S1	Heaw Suwat stream*	14.44639°N 101.36500°E	lotic water
S2	Nong Phak Chi Wildlife Watching Tower*	14.45417°N 101.35917°E	lentic water
S3	Heaw Narok stream*	14.28778°N 101.39250°E	lotic water
S4	Kong Keaw stream*	14.446390°N 101.365000 °E	lotic water
S5	Nang Rong stream	14.30588°N 101.28760°E	lotic water
S6	Kang Kho stream*	14.17670°N 101.59006°E	mixed water
S7	Chao Por Khao Yai Shrine*	14.50661°N 101.38022°E	lotic water
S8	Chao Por Khao Keao Shrine*	14.38393°N 101.39136°E	lotic water
S9	Khao Keao pond*	14.366380, °N 101.402495°E	lentic water
S10	Wang Muang Waterfall*	14.23947°N 101.34393°E	lotic water
S11	Wang Ta Krai	14.32733°N 101.30153°E	mixed water

maintains relatively stable conditions (hot season is quite low and dried in some parts). This site is undisturbed by human activity.

Nong Phak Chi Wildlife Watching Tower (S2; Fig. 1C–D) is a large reservoir situated in an open landscape dominated by grassland and forest margins. During the rainy season, small streams and surface runoff channels flow into the reservoir, the surrounding area includes shallow, swamp-like wetlands with standing water and emergent vegetation. The site remains mostly undisturbed. Although the site is located within one of the park's most popular tourist areas, public access to the actual waterbody is restricted, minimizing direct human disturbance.

Heaw Narok stream (S3; Fig. 1E) is a wide, open-canopy stream with moderately fast flow, characterized by a heterogeneous substrate of gravel and sand. The stream is fringed by semi-deciduous forest and patchy riparian shrubs, forming a relatively open aquatic habitat with ample sunlight exposure. Located downstream of the famous Heaw Narok Waterfall — one of the most well-known tourist attractions in KYNP — the site experiences regular human presence along designated walking trails. However, access to the water itself is restricted for safety and conservation reasons, as visitors are not permitted to enter the stream. This regulatory measure has helped minimize direct disturbance to the aquatic ecosystem.

Kong Keaw stream (S4; Fig. 1F) is a shaded, mid-sized forest stream with moderate flow, located behind the park headquarters. The stream is enclosed by dense canopy with palm-dominated undergrowth and features submerged woody debris and slow-moving pools. A suspension bridge crosses the stream, which splits into multiple small waterfalls and side channels. Although macaque troops frequently visit the area, the site is largely protected from human disturbance.

Nang Rong stream (S5; Fig. 2A) is located outside the boundary of KYNP, near the Khun Dan Prakarn Chon Dam. The stream originates from a waterfall and flows into the downstream section that is hydrologically influenced by dam discharge, especially during

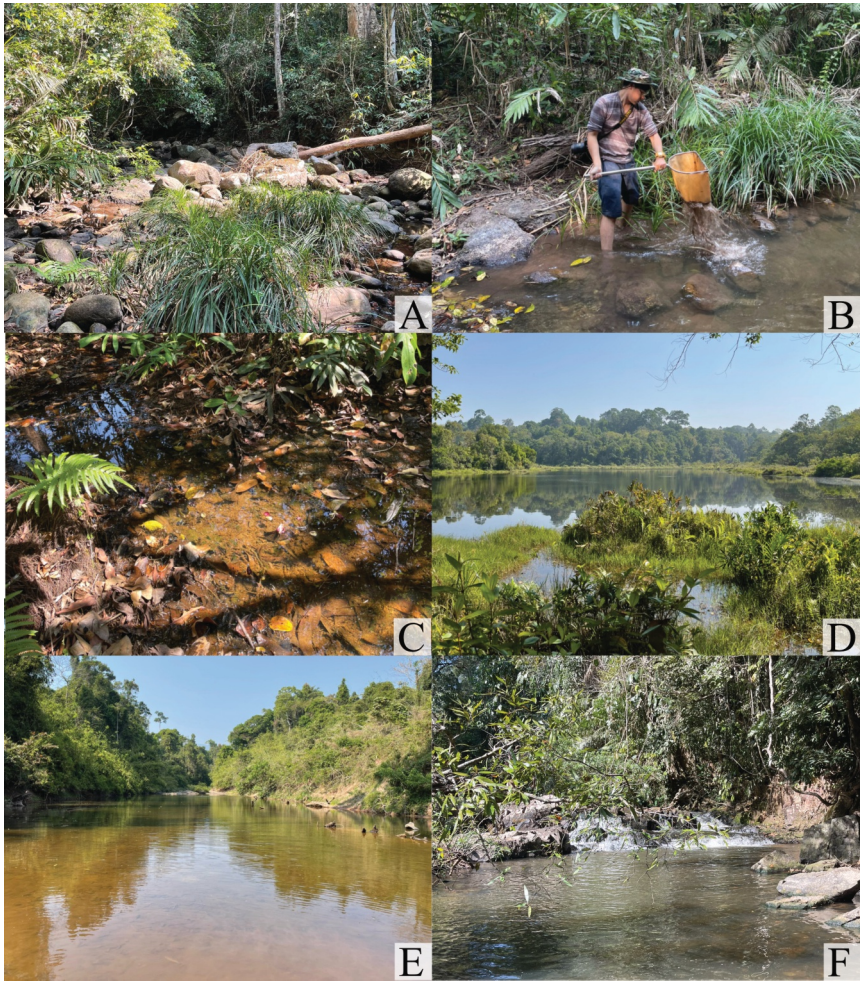

Figure 1. Sampling sites: A, B) Heaw Suwat stream (S1), where the first author collected odonate larvae.; C, D) a small stream and lake at Nong Phak Chi Wildlife Watching Tower (S2); E) Heaw Narok stream (S3); F). Kong Keaw stream (S4).

the rainy season. Water levels in the lower reaches of the stream can fluctuate depending on the release schedule of the dam. Nonetheless, the waterfall section itself retains a consistent water volume during the rainy season and features typical habitat characteristics similar to those of Kong Kaew steam, with a mix of bedrock and gravel substrates, but surrounding agriculture and urban.

Kang Kho stream (S6; Fig. 2B–C) is situated along the outer edge of KYNP and comprises a branching stream system flowing through an open recreational area. The main channel

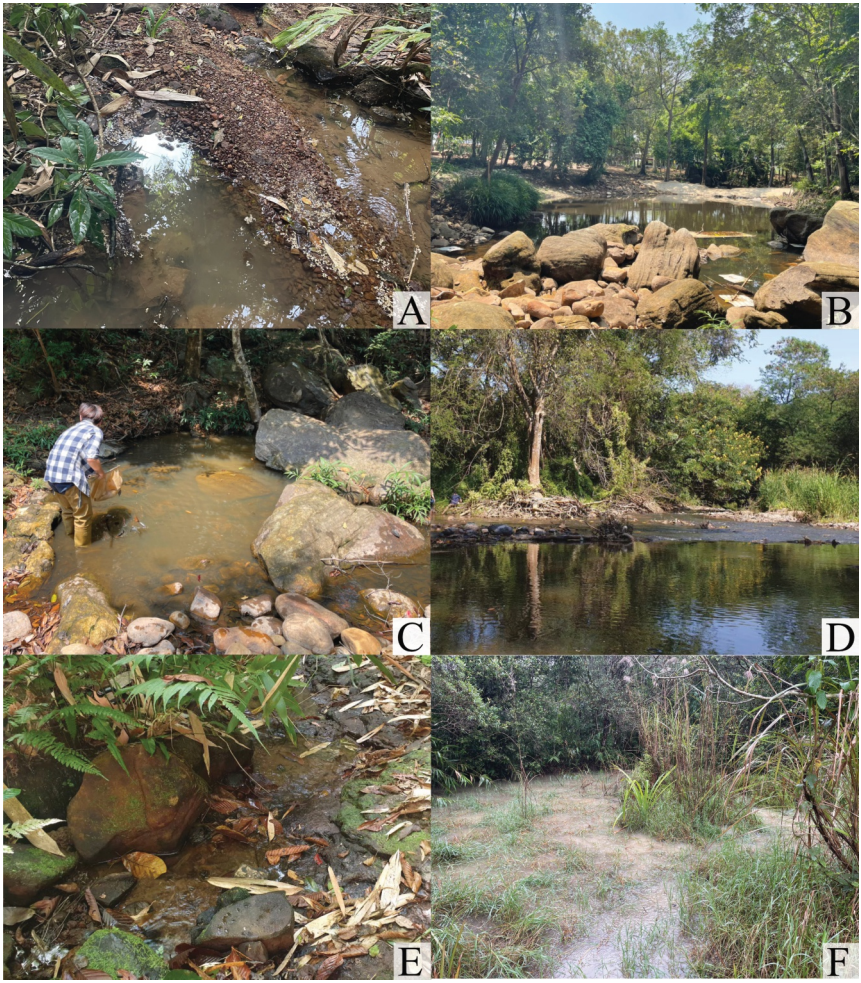

Figure 2. Sampling sites: A) Nang Rong stream (S5); B, C) Kang Kho stream (S6), where the first author collected Odonata larvae. (S6); D) a steam near Chao Por Khao Yai Shrine (S7); E). a stream near Chao Por Khao Keao Shrine (S8); F). Khao Keao pond (S9).

carries a high-water volume during the rainy season, but our study focused on a smaller side branch commonly used for tourism activities. Previous surveys during the dry and cold seasons did not detect Odonata larvae in the mainstream, prompting our sampling in the side branch. This site features a mix of flowing riffles and stagnant pools, with a rocky streambed and artificial cement weirs constructed at intervals. The riparian zone is heterogeneous: one bank is forested while the other is adjacent to a road and open grassland. The anthropogenic modifications have created diverse microhabitats, supporting both lotic and lentic conditions within the same reach.

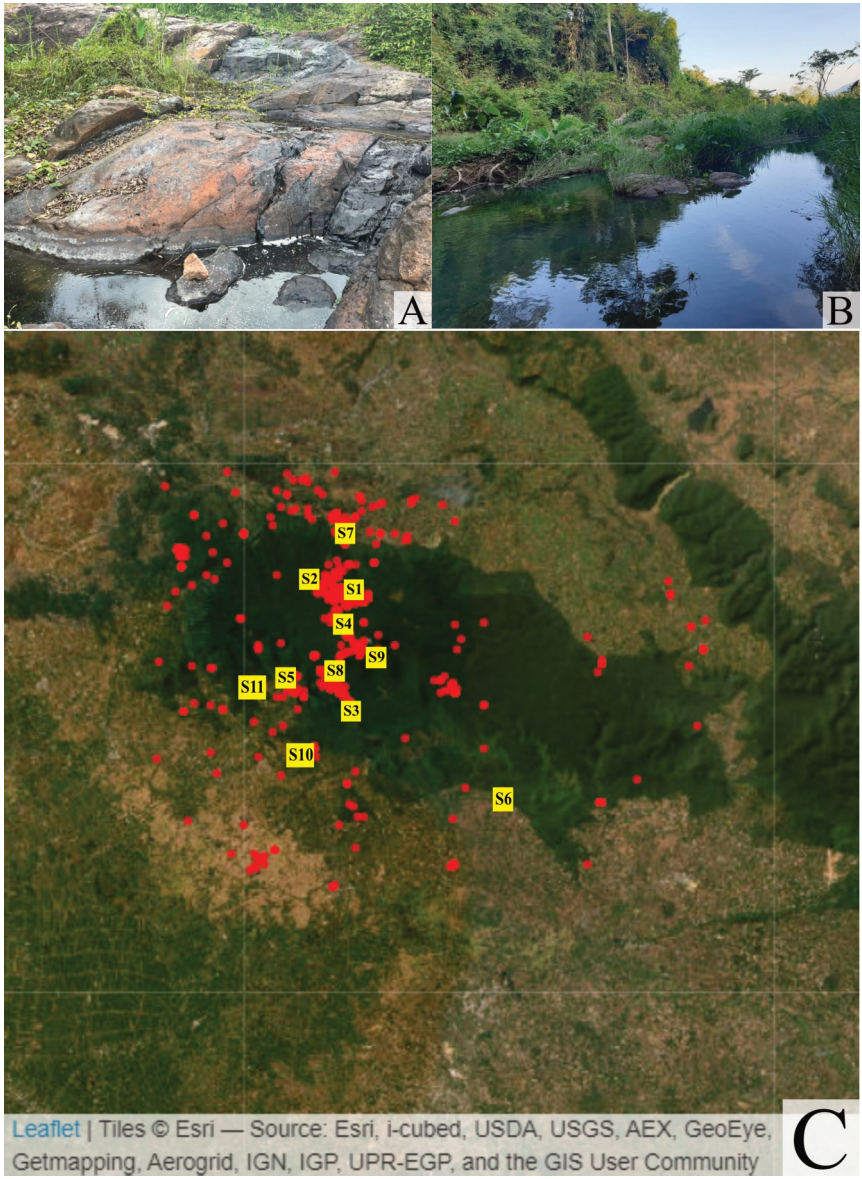

Figure 3. Sampling sites and map of KYNP and adjacent regions: A) Wang Muang Waterfall (S10); B) Wang Ta Krai Waterfall (S11); C) A map showing the observed records from iNaturalist and GBIF (red circle) and sampling sites of the current study (yellow square).

Chao Por Khao Yai Shrine stream (S7; Fig. 2D) is located near the Noen Hom checkpoint, forming a large forest stream that flows through the entrance zone of KYNP. The streambed is composed of a mix of rocky and sandy substrate, and the water volume remains moderate throughout the year. While not designated as a tourist attraction itself, the surrounding area includes a parking facility that serves visitors entering the park. The riparian vegetation is semi-natural, with moderate canopy cover and intermittent shrubs along the banks. In terms of stream morphology and flow characteristics, this site closely resembles Heaw Narok stream.

Chao Por Khao Keao Shrine stream (S8; Fig. 2E) is a small, shaded forest stream situated along the trail to Pha Trom Jai, located just behind the Chao Por Khao Keao Shrine. The stream is approximately 50 meters in length and characterized by shallow water levels and high canopy cover. The substrate is dominated by large boulders and leaf-litter deposits, with no exposed bedrock observed.

Khao Keao pond (S9; Fig. 2F) is a small seasonal pond situated on lateritic soil, characterized by a mostly open habitat surrounded by dense grasses and sedges. The pond holds water primarily during the rainy season, forming a shallow and temporally variable wetland. Vegetation along the margins consists predominantly of herbaceous plants. This site is maintained as a wildlife mineral lick (salt lick) area, attracting various forest mammals, including Asian elephants (*Elephas maximus*) and wild boars (*Sus scrofa*).

Wang Muang Waterfall (S10; Fig. 3A) comprises a seasonal flow system over lateritic bedrock, with sparse canopy cover and a rocky substrate. Although formerly designated as a recreational site within the national park, the area has been abandoned for a prolonged period and currently receives no tourist visitation. Water flows intermittently across exposed bedrock, forming a small seasonal waterfall. Further downstream, the site transitions into a medium-sized stream with mostly slow or stagnant water during the dry season. Aquatic vegetation is well-developed along the stream margins and within shallow zones.

Wang Ta Krai (S11; Fig. 3B) is a privately managed ecotourism site that features a large stream flowing through the area, along with several small streams and ponds. The mainstream closely resembles Kang Kho stream in terms of physical characteristics, with a rocky bed and moderate canopy cover. The site is heavily used for recreational purposes, and large numbers of tourists frequently access the mainstream. However, the surveys in this study were conducted in the less-disturbed stream and the pond area, where human impact is minimal and natural habitat structure remains relatively intact.

Methods

Data collection

Odonate sampling followed the standardized protocol outlined by Cezário et al. (2021). Larvae and exuviae were collected using D-frame nets from various microhabitats, while adult specimens were observed and collected. Fully developed larvae were transported to the laboratory and reared in earthenware containers. Unsuccessfully reared larvae and exuviae were preserved in absolute ethanol. Adult specimens were initially stored in paper envelopes, then treated with 100% acetone for 6–8 hours before being air-

dried. Photographic documentation obtained during fieldwork was also used to assist in species identification and to validate certain additional records.

Voucher specimens were deposited in the Entomology Collection of the Forest and Plant Conservation Research Office, Department of National Parks, Wildlife and Plant Conservation (ECNP-DNP), Bangkok, Thailand, and in the private collection of Tosaphol Saetung Keetapithchayakul.

Citizen science

As part of a citizen science initiative to document the diversity of Odonata in KYNP, a field survey was organized during 23–25 September 2023. Participants were recruited in advance through an online questionnaire aimed at assessing their interest and availability, resulting in a selected group of approximately 10 people. These citizen scientists, including nature enthusiasts and amateur naturalists, were briefed on basic field protocols and identification methods prior to the excursion. Under supervision, participants actively contributed to the search, observation, and photographic documentation of adult odonates within the KYNP. The data collected during this trip were subsequently reviewed and validated for inclusion in the species occurrence dataset used in this study.

Participant engagement and field data collection

A total of 10 participants took part in the two-day Citizen Science excursion at KYNP, comprising five graduate school students and five naturalists (including odonatologists and dragonfly enthusiasts). During the trip, participants observed and studied both adult and larval Odonata, as follows:

Adult surveys: Using aerial sweep nets during peak flight periods and photographing specimens, participants documented key morphological traits, including wing venation, body coloration, and abdominal markings. After data entry, all captured imagos were safely released.

Larval surveys: Participants collected larvae (including exuviae) from various sampling sites. Odonata larvae and exuviae were collected using D-frame nets and hand picking. Collected specimens were temporarily housed in glass or plastic containers for on-site identification (typically to family and genus level), focusing on diagnostic features such as habitus and caudal lamellae. After identification, most larvae were released at their collection sites.

Data from external sources

Odonate occurrence data used in this study were obtained from the iNaturalist online database (www.inaturalist.org) and GBIF (Global Biodiversity Information Facility: www.gbif.org) by querying research-grade records of the order Odonata within a defined polygonal region encompassing parts of eastern and northeastern Thailand. The region of interest was delimited based on geographic coordinates corresponding to field-based conservation and biodiversity research priorities. Particular iNaturalist observations can be retrieved from there by their links of the following format: https://inaturalist.org/observations/x, where x is the observation number, a digital value of any number of digits (in our cases 8 to 9).

Data retrieval was conducted using the rinat and rgbif package in R software, with spatial filtering applied to include only those records falling within the custom polygon. To ensure taxonomic reliability, only research-grade observations — i.e., those confirmed by multiple users and accompanied by photographic evidence — were included. The resulting dataset was visualized and filtered spatially using the sf and leaflet packages in R. The derived dataset of this study was deposited in GBIF database (GBIForg 2025). Supplementary distributional data were compiled from external sources, including the Facebook group “Dragonflies of Thailand”.

Data analysis

This study used R software with the tidyverse, patchwork, ggrepel, ggplot2, dplyr, and lubridate packages to visualize our KYNP Odonata data into three charts (Figure 4). First, a line plot illustrates the total number of Odonata observations recorded each year from KYNP, highlighting how sampling effort and data availability have increased over time. By visualizing annual counts, we can see the sharp rise in recorded observations in recent years. Second, a line plot shows the total number of dragonfly and damselfly observations recorded in each month (all years combined). We can clearly see seasonal peaks and dips in overall observation effort or odonate activity in KYNP. The last one is a bar chart showing the species richness observed in each month. It highlights which months have the highest overall species richness in KYNP.

Results

This study presents a list of observations of 106 odonate species, including 45 damselflies and 61 dragonflies. Of these, 78 species were recorded during the authors’ survey, while an additional 28 species were documented by the citizen science community (see Table 2 in Appendix). Based on the iNaturalist and GBIF database (2003–2024), a total of 2,974 Odonata records were retrieved for KYNP and its adjacent areas, of which 1,662 (55.9%) were documented during the rainy season. Annual trend (Figure 4) remained low throughout the mid-2000s but began to rise markedly after 2015. By 2021, observations reached 265, then surged to 272 in 2022, peaked at 969 in 2023, and remained high at 825 in 2024. This steady increase in annual reports reflects both growing survey efforts and heightened community engagement on iNaturalist and GBIF.

When all years are combined, monthly observation totals of Odonata peak in October (512 records), May (313 records), and September (314 records), aligning with early- and late-monsoon adult emergences. Species richness per month closely mirrors these abundance peaks (Figure 4): October records the highest species richness (86), followed by May (76) and September (62). In contrast, late-dry-season months—March (170 records; 43 species) and April (152 records; 45 species)—exhibit both the fewest observations and species richness. During June–July, both the number of observations and species richness were low (148 and 152 records; 44 species), owing to heavy monsoon rains and associated flash flooding in KYNP, which resulted in the closure of many survey areas within the park. During December, both the total number of odonate observations and the recorded species richness decline to their lowest annual values. This downturn corresponds with a shift to cooler ambient temperatures, which inhibit adult emergence and flight activity in many Odonata species. Simultaneously,

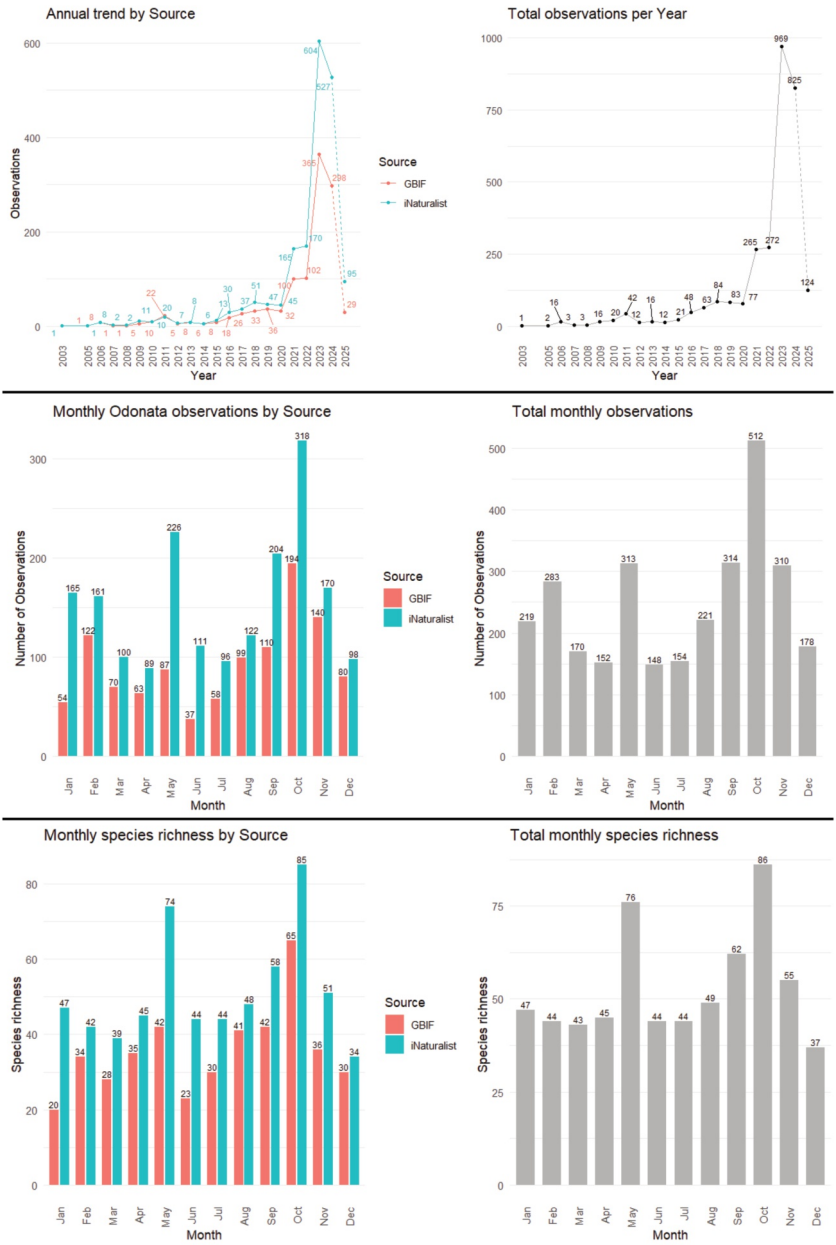

Figure 4. The plot graphs illustrate trends in Odonata observations recorded from Khao Yai National Park (KYNP) and adjacent regions, based on data sourced from iNaturalist and GBIF.

a marked increase in tourist visitation imposes logistical constraints on park operations and may disrupt routine monitoring protocols. Finally, the New Year holiday period further reduces researcher presence in the field and lowers sampling intensity, collectively driving the observed seasonal minimum in data collection. October represents the peak of Odonata records in KYNP (268 observations over 21 years) because, in the late rainy season, water levels remain high enough for larvae to emerge into adults, resulting in abundant emergence and mating activity. Additionally, rainfall diminishes in October, improving visibility and facilitating field surveys, while riparian vegetation remains lush. Consequently, both common and rare species are most readily observed, making October the optimal time for comprehensive data collection on species diversity and life-cycle dynamics. These concordant patterns of observation and species richness delineate optimal windows for field surveys while establishing a multi-decadal baseline for detecting future phenological or ecological shifts.

New odonate records for KYNP

The following five odonate species are new additions to the Odonata fauna of KYNP:

- *Gomphidia kruegeri* Martin, 1904 was recorded based on a photo via Facebook group "Dragonflies of Thailand" by Wilawan Tangngekkee (20.06.2024) (Figure 5A).
- *Atratothemis reelsi* Wilson, 2005 was recorded based on a photo via Facebook group "Dragonflies of Thailand" by Wilawan Tangngekkee (17.05.2024) (Figure 5B).
- *Copera chantaburii* Asahina, 1984 was recorded based on a photo via iNaturalist database by John Sim (17.10.2023) (Figure 5C).
- *Nannophyopsis clara* (Needham, 1930) was recorded based on a larva. This species was compared with Yeh & Lien (1995), Novelo-Gutiérrez & Sites (2024), and Phan et al. (2025). The *N. clara* larva was identified based on diagnostic characteristics (Figure 6), i.e., 12–13 pairs of premental setae, 9+1 premental setae, dorsal spines on abdominal segments 4–9, lateral spines on abdominal segments 7–9. The abdominal segment 10 and caudal appendages reduced at abdominal segment 9.
- *Protosticta khaosoidaoensis* Asahina, 1984 was recorded based on male specimens from S2 and photos via Facebook group "Dragonflies of Thailand" (Figure 7). Notably, pale lines on the dorsal carina in males are absent. These markings likely fade with age.

Taxonomic notes on some damselflies and dragonflies previously reported from KYNP

Keetapithchayakul et al. (2023) reported *Epopthalmia frontalis* Selys, 1871 from KYNP. However, based on Kosterin et al. (2025), we reidentified the specimens as *E. vittata* Burmeister, 1839 (Figure 5D), due to the presence of a characteristic heart-shaped spot on the cleft of the frons. In contrast, *E. frontalis*, a similar but less widespread species in Thailand, exhibits two separated spots on the cleft of the frons.

According to a recent study by Hopkins et al. (2025), the identification of *Lestes praemorsus decipiens* (Hagen in Selys, 1862) in previous publications, including Keetapithchayakul et al. (2023), should be corrected to *L. decipiens* Kirby, 1893.

Hopkins (2024) demonstrated that *Aciagrion occidentale* Laidlaw, 1919 and its senior synonym, *A. paludense* Fraser, 1922, are not conspecific. Consequently, the record of *A. occidentale*

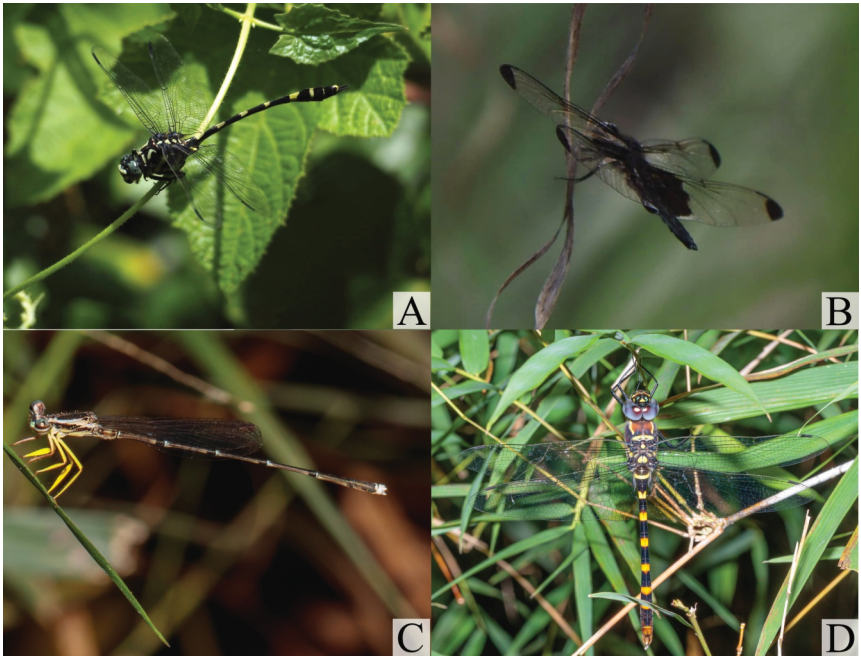

Figure 5. Photographs of odonate species from the Facebook group "Dragonflies of Thailand": A) *Gomphidia kruegeri* Martin, 1904 (photo by W. Tangngekkee); B) *Atratothemis reelsi* Wilson, 2005 (photo by W. Tangngekkee); C) *Copera chantaburii* Asahina, 1984 (photo by John Sim); D) *Epopthalmia vittata* Burmeister, 1839 (photo by John Sim).

from KYNP in Keetapithchayakul et al. (2023) has been reidentified as *A. paludense* Fraser, 1922, representing a new record for Thailand.

Progress in recognition and identification of odonate larvae

In a recent study by Keetapithchayakul et al. (2024) and Nguyen et al. (2024), the larval stages of *Argiocnemis rubescens rubeola* Selys, 1877 and *Dysphaea gloriosa* Fraser, 1922 were described, based partly on specimens from the study of Odonata fauna in KYNP and adjacent regions (Keetapithchayakul et al. 2023). Despite this progress in larval stage descriptions, over 40% of regional species remain unknown in reference to their larvae and await formal descriptions.

During this study, larvae were found that were previously unidentifiable due to lack of images or figures, including *Amphithemis curvistyla* Selys, 1891, *Sympetrum thailandensis* Makbun, 2023 (Figure 8A-D), *Idionyx thailandicus* (Hämäläinen, 1985), *Aciagrion approximans* (Selys, 1876), *Agriocnemis nana* (Laidlaw, 1914), *Pseudagrion australasiae* Selys, 1876, *P. williamsoni* Fraser, 1922, and *Indolestes anomalus* Fraser, 1924 (Figure 8E). The larvae of *A. nana*, *Oro-*

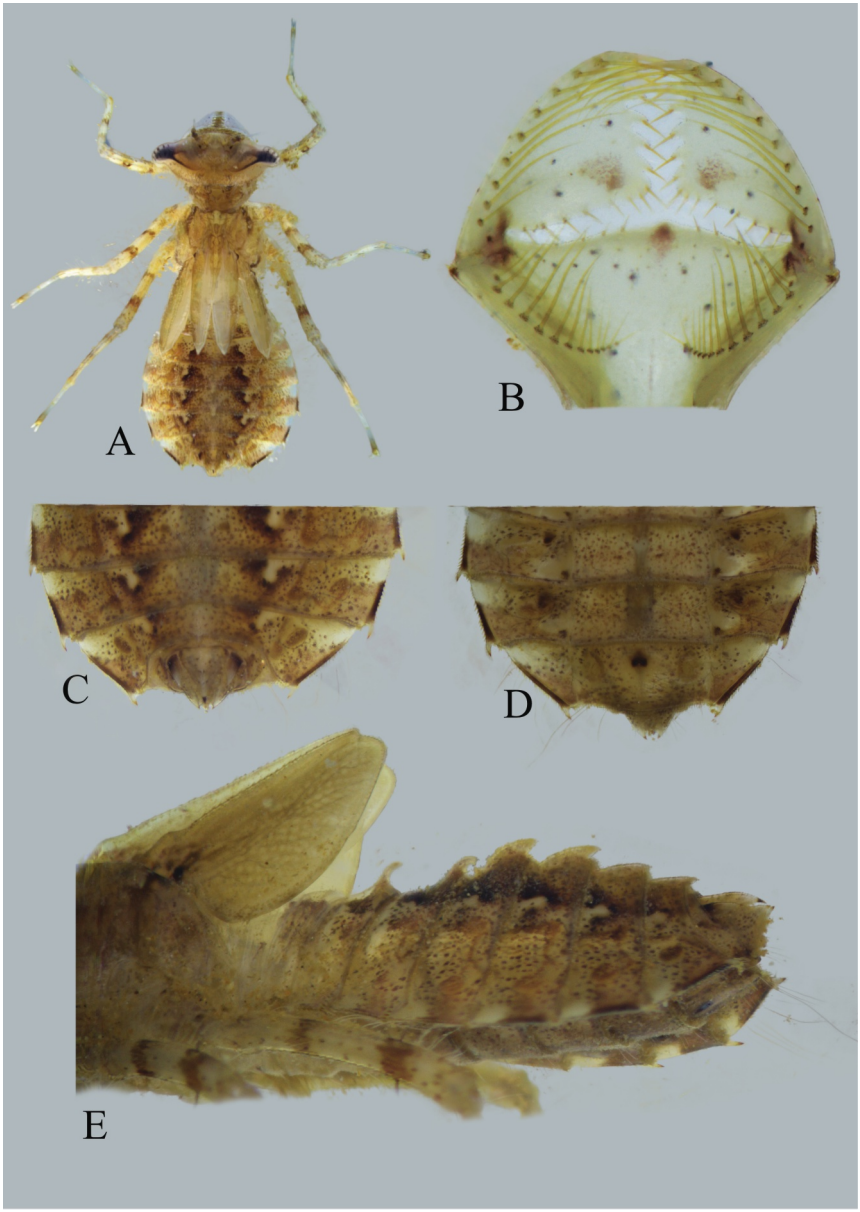

Figure 6. The larva of *Nannophyopsis clara* (Needham, 1930) from S2: A) habitus; B) prementum, dorsal view; C) abdominal segment 7-9, dorsal view, D) abdominal segment 7-9, ventral view; E) synthorax and abdomen, lateral view.

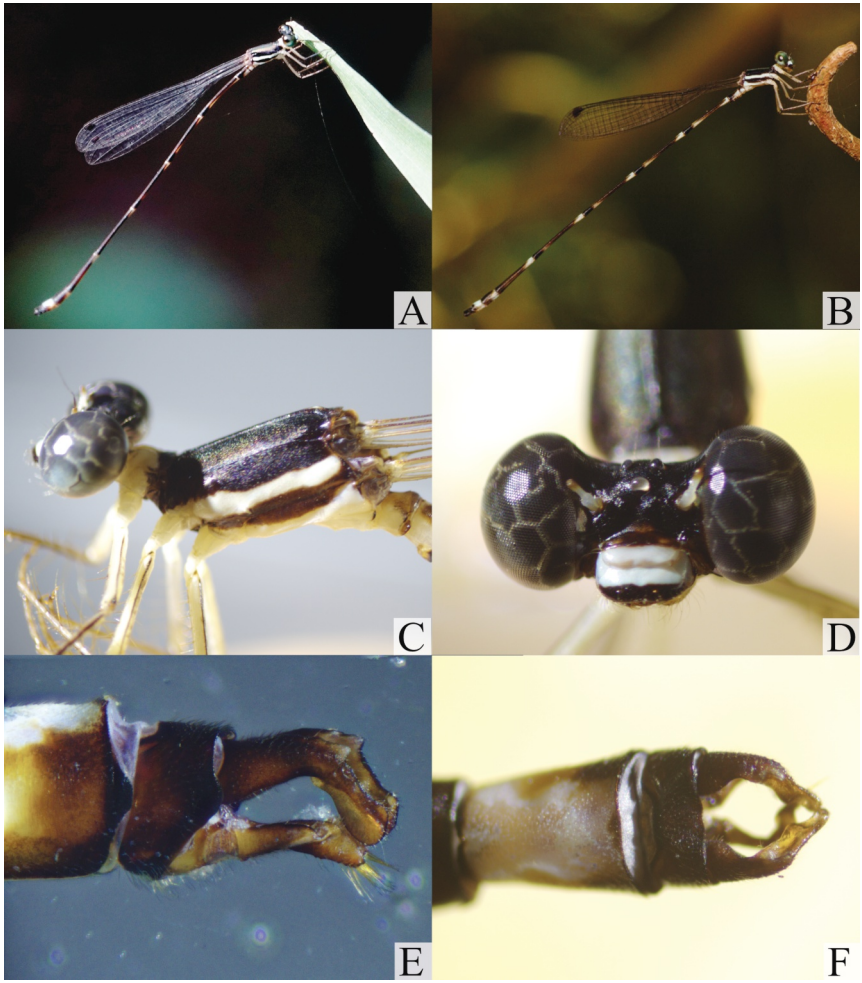

Figure 7. Photographs of male *Protosticta khaosoidaoensis* Asahina, 1984 from the Facebook group "Dragonflies of Thailand," along with its diagnostic characters: A) in life from S2 (photo by U. Treesucon); B) in life from S1 (photo by T. Thitiarchagul), C) Head and thorax, lateral view, D) Head, frontal view; E) abdomen and caudal appendages, lateral view; F) abdomen and caudal appendages, dorsal view.

lestes octomaculatus Martin, 1902 (Figure 8F), *P. australasiae*, and *P. williamsoni* were compared and identified using specimens from TSK's collection. Meanwhile, the larvae of *S. thailandensis, Z. iris, I. thailandicus, Ac. approximans,* and *In. anomalus* were successfully reared and identified based on adult specimens.

Figure 8. Photographs of odonate larvae and exuviae: A, B) *Amphithemis curvistyla*; C, D) *Sympetrum thailandensis*; E) *Indolestes anomalus*; F) *Orolestes octomaculatus* (F–1 larva).

Khao Yai Dragonfly Citizen Science Activity- Exploring the Unexpected Diversity of odonate at KYNP - Dates: 23–24 September 2023 (Figure 9)

Educational outcomes for the participants

Participants reported significant gains in both formal knowledge and practical skills related to Odonata biology, based on Cezário et al. (2021) and Keetapithchayakul et al. (2023). Prior to the activity, pre-survey questionnaires revealed that although most participants were aware

Figure 9. Overview of Khao Yai Dragonfly Citizen Science Activity trip. A) participants at S2, (left to right): Mr. Thanayos Pawvesese, the fourth author, the first author, Dr. Sirikamon Phlaingam, Ms. Chanikan Katnoum, Mr. Worradon Ngambunkup and Ms. Nattavadee Tipsut; B) participants at Pha Trom Jai view spot – front row, (left to right): the first author, Mr. Uthai Treesucon (a Thai senior expert in birdwatching), the second author; back row (left to right): Ms. Suphilak Chamratthanasan, Mr. Thanayos Pawvesese, the fourth author, Ms. Chanikan Katnoum, Ms. Nattavadee Tipsut and Mr. Tosaporn Thitiarchagul; C) participants heading to S2; D) participants observing larvae of *Sympetrum thailandensis* and *Indolestes anomalus* at S9; E) participants observing dragonflies and damselflies at S8; F) participants observing dragonflies and damselflies at S2.

that dragonflies possess aquatic larvae and were broadly familiar with the general appearance of both larval and adult stages, only approximately 10% were able to accurately identify adult specimens at the family level or larvae at the suborder level. This outcome is likely attributable to the fact that many participants had limited prior experience with aquatic insects — including Odonata — as their primary interest lay in other taxonomic groups such as reptiles, plants, or marine organisms.

Post-survey questionnaires indicated that most participants successfully identified at least the genera of dragonflies and could recognize families and genera based on diagnostic characters. Through hands-on collection and observation, participants gained direct insight into the metamorphic stages of Odonata.

Additionally, participants showed a significant improvement in understanding each larval family's preferred habitats — flowing versus standing water and other microhabitats — and how these environmental conditions influence larval development and the timing of adult emergence.

Participant feedback and future directions

Post-event surveys indicated overwhelmingly positive outcomes: more than 95 % of respondents agreed they "learned substantially more about dragonfly identification and life cycles and expressed interest in future workshops, and some of them expressed interest in volunteering as mentors for new participants in the next event.

The two-day Citizen Science event at KYNP successfully engaged a diverse group of volunteers in systematic surveys of both adult and larval dragonflies. During the survey, participants recorded 47 Odonata species, including 23 dragonfly and 24 damselfly species, as summarized in Table 2.

The present study demonstrates the value of integrating year-round field sampling with community-based Citizen Science initiatives. Citizen participation not only broadens the spatial and temporal coverage of Odonata monitoring but also generates datasets that are often more robust than those obtained through traditional surveys alone (Dickinson et al. 2012; Cezário et al. 2021; Della Rocca et al. 2024). By involving local communities in data collection, conservation outcomes are enhanced through increased public awareness, ecological stewardship, and stronger connections between people and their environment — an especially critical achievement in regions facing growing anthropogenic pressures from tourism and development (Conrad & Hilchey 2011; Kobori et al. 2016; Ferreira et al. 2024).

Digital biodiversity platforms further complement these efforts by providing accessible and continuously updated records. iNaturalist, for example, facilitates rapid community-sourced observations that capture recent survey activities within specific areas such as national parks. In contrast, GBIF aggregates long-term, specimen-verified data contributed by museums, research institutions, and monitoring programs, with records in some cases extending back to the 1960s. Although overlap between the two sources is common, iNaturalist contributes larger volumes of recent, fine-scale data, whereas GBIF provides historical depth and voucher-backed reliability. The combined use of both platforms therefore yields a more complete and reliable baseline for understanding Odonata distributions.

Field sampling in this study also provided insights into ecological patterns, particularly regarding habitat preferences. Species inhabiting temporary water bodies displayed distinctive adaptations that allow rapid development before habitat desiccation, as exemplified by larvae of *Indolestes, Sympetrum*, and *Orolestes*, which were consistently collected from shallow lentic pools (Lieftinck 1939, 1960; Ishida 1996). These findings are consistent with earlier reports of microhabitat specificity in tropical Odonata and represent the first records of larval stages for these genera in Southeast Asia. Although a detailed analysis of phenological patterns was beyond the present scope, the baseline data reported here provide a foundation for future ecological and conservation research.

Conclusion

Through author observations and citizen-science contributions, a total of 106 odonate species were documented, of which five represent new additions, raising the total known fauna in KYNP from 142 to 147 species. Notably, rainy-season sampling contributed five newly recorded species for KYNP, one species newly recorded for Thailand, and nine species whose larval stages had not previously been described or figured, thereby enhancing taxonomic accuracy and providing a more comprehensive baseline for future biodiversity assessments.

By integrating larval-stage documentation, we gained insights into habitat preferences, established a reference for larval morphology in regional collections, and collectively improved odonate monitoring while strengthening the park's long-term freshwater biodiversity research.

During the citizen science event, participants acquired hands-on experience in species identification, life-cycle documentation, and aquatic ecosystem monitoring. Data collected — particularly new larval records — were incorporated into the national biodiversity database and informed local habitat-protection recommendations. Equally important, the activity deepened participants' ecological literacy, empowered future 'budding odonatologists', and fostered long-term community science collaborations to support freshwater conservation efforts.

Moving forward, future work should focus on maintaining systematic, habitat-stratified larval sampling across additional stream and pond microhabitats, incorporating molecular barcoding, and conducting seasonal re-surveys to detect shifts in emergence patterns under climate variability. These efforts will ensure that KYNP's odonate database remains comprehensive and up-to-date.

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Appendix

Table 2. Species list found during the survey and the citizen scientific community.

*** indicates the species that were found during citizen science activity**

FB indicates Facebook group "Dragonflies of Thailand" (https://www.facebook.com/groups/DragonfliesOfThailand)

iNat indicates iNaturalist online database (www.inaturalist.org)

TT	Species	Recorded site and source	Date	Reference
	Suborder Anisoptera			
	Family Aeshnidae			
1	**Anax guttatus* (Burmeister, 1839)	S2, 4, 9,11		
2	*Indaeschna ornithocephala* (McLachlan, 1896)	FB	05.10.2024	Tosaporn Thitiarchagul
3	*Gynacantha basiguttata* Selys, 1882	FB	15.06 & 11.10.2024	Tosaporn Thitiarchagul
4	*Gynacantha saltatrix* Martin, 1909	FB	12.10.24	Wat Wongpan
5	*Gynacantha subinterrupta* Rambur, 1842	S1, 4, 10		
6	**Tetracanthagyna waterhousei* McLachlan, 1898	S1, 3, 4, 5, 6 ,7, 8, 11		
	Family Gomphidae			
7	**Burmagomphus divaricatus* Lieftinck, 1964	S1, S6, S10		
8	*Euthygomphus yunnanensis* (Zhou & Wu, 1992)	FB	08.09.2023	Wilawan Tangngekkee
9	*Gomphidia abbotti* Williamson, 1907	S1, 5, 7		
10	*Gomphidia kruegeri* Martin, 1904	FB	20.06.2024	Wilawan Tangngekkee
11	*Gomphidictinus perakensis* (Laidlaw, 1902)	S1, 3, 7		
12	**Heliogomphus selysi* Fraser, 1925	S1, 8		
13	*Ictinogomphus decoratus* (Selys, 1854)	S2, 11		
14	*Macrogomphus kerri* Fraser, 1932	S1, 3		
15	**Microgomphus svihleri* (Asahina, 1969)	S1, 3, 5, 7, 8, 10, 11		
16	*Nychogomphus duaricus* (Fraser, 1924)	iNat	09.09.2023	190547764
17	*Paragomphus capricornis* (Förster, 1914)	S1, 3, 11		
18	*Phaenandrogomphus asthenes* Lieftinck, 1964	S1, 3, 11		
	Family Libellulidae			
19	**Acisoma panorpoides* Rambur, 1842	S2, 11		
20	*Aethriamanta brevipennis* (Rambur, 1842)	iNat	18.05.2023	187987614
21	**Amphithemis curvistyla* Selys, 1891	S9		
22	*Atratothemis reelsi* Wilson, 2005	FB	17.05.2024	Wilawan Tangngekkee
23	**Brachydiplax chalybea* Brauer, 1868	S10		
24	*Brachydiplax farinosa* Krüger, 1902	iNat	17.08.2024	236479998
25	**Brachythemis contaminata* (Fabricius, 1793)	S2, 11		
26	*Camacinia gigantea* (Brauer, 1867)	FB	21.06.24	Wilawan Tangngekkee
27	*Cratilla lineata* (Brauer, 1878)	FB	21.06.24	Wilawan Tangngekkee

TT	Species	Recorded site and source	Date	Reference
28	*Diplacodes nebulosa* (Fabricius, 1793)	S2, 10, 11		
29	**Diplacodes trivialis* (Rambur, 1842)	S2, 12		
30	*Hydrobasileus croceus* (Brauer, 1867)	S2, 11		
31	*Indothemis carnatica* (Fabricius, 1798)	iNat	28.07.2024	33640921
32	*Indothemis limbata* (Selys, 1891)	iNat	28.07.2024	233640845
33	*Lyriothemis elegantissima* Selys, 1883	FB	08.06.2023	Uthai Treesucon
34	*Nannophyopsis clara* (Needham, 1930)	S2		
35	**Neurothemis fluctuans* (Fabricius, 1793)	S2, 5, 8		
36	**Neurothemis fulvia* (Drury, 1773)	S2, 11		
37	**Onychothemis testacea* Laidlaw, 1902	S1, 3, 4, 5, 6, 7, 10		
38	*Orthetrum glaucum* (Brauer, 1865)	S1,3, 7		
39	*Orthetrum luzonicum* (Brauer, 1868)	iNat	28.07.2024	233640777
40	**Orthetrum pruinosum* (Burmeister, 1839)	S1, 2, 3, 4, 6, 7, 11		
41	**Orthetrum sabina* (Drury, 1773)	S2, 5, 7, 11		
42	*Orthetrum triangulare* (Selys, 1878)	iNat	28.07.2024	233640679
43	*Pantala flavescens* (Fabricius, 1798)	S2		
44	*Pseudothemis jorina* Förster, 1904	S4		
45	*Rhodothemis rufa* (Rambur, 1842)	S2, 11		
46	**Rhyothemis phyllis* (Sulzer, 1776)	S2, 9, 11		
47	*Rhyothemis plutonia* Selys, 1883	S2, 11		
48	**Rhyothemis triangularis* Kirby, 1889	S2		
49	**Rhyothemis variegata* (Linnaeus, 1763)	S2. 9, 11		
50	**Sympetrum hypomelas* (Selys, 1884)	S9		
51	**Sympetrum thailandensis* Makbun, 2023	S9		
52	**Tetrathemis platyptera* Selys, 1878	S2		
53	*Tholymis tillarga* (Fabricius, 1798)	S2, 11		
54	*Tramea transmarina* Brauer, 1867	S2, 11		
55	**Trithemis aurora* (Burmeister, 1839)	S1, 2, 3, 6		
56	*Trithemis festiva* (Rambur, 1842)	FB	21.06.2024	Wilawan Tangngekkee
57	**Zygonyx iris* Selys, 1869	S1, 3, 4, 5, 6, 7, 10,11		
	Family Macromiidae			

TT	Species	Recorded site and source	Date	Reference
58	*Epophthalmia vittata* Burmeister, 1839	S1		
59	*Macromia* sp.	S1, 3, 4, 5, 6, 7, 10,11		
	Family Synthemistidae			
60	*Idionyx thailandicus* Hämäläinen, 1985	S1, 5, 6, 10		
61	*Macromidia genialis* Laidlaw, 1923	S1		
	Suborder Zygoptera			
	Family Calopterygidae			
62	**Neurobasis chinensis* (Linnaeus, 1758)	S1, 3, 4, 5, 6, 7, 10,11		
63	**Vestalis gracilis* (Rambur, 1842)	S1, 4, 10		
	Family Chlorocyphidae			
64	**Aristocypha fenestrella* (Rambur, 1842)	S3, 4, 5, 7, 8, 11		
65	**Heliocypha perforata* (Percheron in Guérin-Méneville & Percheron, 1835)	S3, 4, 5, 7, 8, 11		
66	*Libellago lineata* (Burmeister, 1839)	S3, 4, 7, 11		
	Family Coenagrionidae			
67	**Aciagrion approximans* (Selys, 1876)	S2		
68	*Aciagrion borneense* Ris, 1911	FB	24.09.2023	Uthai Treesucon
69	*Aciagrion hisopa* (Selys, 1876)	iNat	23.06.2024	226024676
70	*Aciagrion pallidum* Selys, 1891	iNat	06.05.2023	252346111
71	**Agriocnemis femina* (Brauer, 1868)	S2, 4,8, 11		
72	**Agriocnemis minima* Selys, 1877	S2, 11		
73	**Agriocnemis pygmaea* (Rambur, 1842)	S2		
74	**Archibasis viola* Lieftinck, 1949	S4		
75	*Argiocnemis rubescens* Selys, 1877	S2, S11		
76	**Ceriagrion auranticum* Fraser, 1922	S2, 11		
77	*Ceriagrion azureum* (Selys, 1891)	S8		
78	*Ceriagrion cerinorubellum* (Brauer, 1865)	FB	24.09.2023	Uthai Treesucon
79	*Ischnura rubilio* Selys, 1876	iNat	18.09.2023	242514057
80	**Ischnura senegalensis* (Rambur, 1842)	S2, 8, 11		
81	*Mortonagrion aborense* (Laidlaw, 1914)	S2		
82	*Paracercion calamorum* (Ris, 1916)	iNat	10.10.2023	188633321

TT	Species	Recorded site and source	Date	Reference
83	**Pseudagrion australasiae* Selys, 1876	FB	24.09.2023	Uthai Treesucon
84	**Pseudagrion microcephalum* (Rambur, 1842)	S2, 11		
85	**Pseudagrion pruinosum* (Burmeister, 1839)	S1, 3, 4, 6, 10, 11		
86	**Pseudagrion rubriceps* Selys, 1876	S1, 6, 11		
	Family Euphaeidae			
87	*Dysphaea gloriosa* Fraser, 1938	S1, 4		
88	**Euphaea masoni* Selys, 1879	S1, 3, 4, 5, 6, 7, 10, 11		
89	**Euphaea ochracea* Selys, 1859	S1, 3, 10, 11		
	Family Lestidae			
90	**Indolestes anomalus* Fraser, 1946	S8		
91	*Indolestes birmanus* (Selys, 1891)	S8		
92	*Lestes dorothea* Fraser, 1924	S2, 11		
93	*Orolestes octomaculatus* Martin, 1902	S2		
	Family Philosinidae			
94	*Rhinagrion hainanense* Wilson & Reels, 2001	FB	24.09.2024	Uthai Treesucon
95	**Rhinagrion viridatum* Fraser, 1938	S1, 6, 8		
	Family Platycnemididae			
96	*Coeliccia didyma* (Selys, 1863)	S8, 10		
97	*Coeliccia kazukoae* Asahina, 1984	iNat	17.09.2024	242263496
98	*Coeliccia nigrescens* Laidlaw, 1931	FB	23.09.2024	Uthai Treesucon
99	**Coeliccia poungyi* Fraser, 1924	S1, 3, 4, 5, 6, 10		
100	*Copera chantaburii* Asahina, 1984	iNat	17.10.2023	189450889
101	**Copera marginipes* (Rambur, 1842)	S1, 2, 3, 4, 5, 6, 7, 10,11		
102	**Copera vittata* (Selys, 1863)	S3, 6		
103	*Onychargia atrocyana* Selys, 1865	S2, 11		
104	**Prodasineura autumnalis* (Fraser, 1922)	S1, 2, 3, 4, 5, 6, 7, 8, 10,11		
105	*Pseudocopera ciliata* (Selys, 1863)	S2, 11		
	Family Platystictidae			
106	**Protosticta khaosoidaoensis* Asahina, 1984	S2		

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