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Contribution to the knowledge of the Odonata fauna of Khao Yai National Park and the adjacent regions in Thailand

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Abstract

The diversity and distribution of dragonflies and damselflies were investigated at Khao Yai National Park (KYNP) during January 2019 – March 2022. Adults and larvae of 78 species were collected from 26 sampling sites including lotic and lentic habitats. The updated odonate checklist of KYNP and adjacent areas brings the total number of species from 109 to 142 species, of which 33 species are new records. The Libellulidae account for more than one third of the regional fauna with the highest number of species, followed by Coenagrionidae, Gomphidae, and Platycnemididae, respectively. Differences between the numbers of Odonata species recorded using larval records, adult records, and observational and photographic records are discussed. Multivariate analyses were performed which revealed a strong correlation between the habitat types (lotic, lentic and “mixed” water bodies) and odonate species present. Species richness between those three habitat types was similar. Two-way cluster analysis showed a strong association between three groups of odonate species and three groups of microhabitats (rocky-lotic, debris-riparian-lotic, lentic habitats).

Key words: Odonata, dragonfly, damselfly, larva, rearing, Khao Yai National Park, Thailand

Introduction

The Khao Yai National Park (KYNP) is a well-known National Park in part of Dong Phayayen–Khao Yai Forest Complex (a UNESCO World Heritage Site) which includes the headwaters of the major rivers of the northeastern and eastern regions of Thailand. The adjacent areas of KYNP are under intense pressure from ongoing anthropogenic disturbances (human settlement encroachment, tourism, highway construction, wildlife smuggling, and illegal logging). These disturbances are degrading and threatening the ecology of freshwater waters and organisms.

Collecting wildlife specimens (including carcasses and exuviae) within protected areas in Thailand requires a written permit from the National Parks, Wildlife and Plant Conservation Department (DNP), according to the Wild Animal Reservation and Protection Act, B.E. 2019. The process of obtaining the permit can be complicated and takes a long time. In particular, the DNP needs to review a proposal in which the proposed data collection activities are supervised by a qualified professional, such as a wildlife biologist or ecologist. This is to ensure that the data collection is conducted in a safe and responsible manner and that any potential impacts on the environment and wildlife are minimized. Normally, the process will take 3–8 months. Such administrative processes greatly complicate the study of dragonflies in Thailand (Hämäläinen 2017). Because of this many research articles on the Thai Odonata report new distributions exclusively based on photographic evidences or specimens collected only from outside the protected areas (Ferro et al. 2009; Kosterin et al. 2011; Day et al. 2012; Chainthong et al. 2020; Farrell & Makbun; 2020; Saetung et al. 2020; Makbun et al. 2022).

The diversity of Odonata in KYNP is fairly well known. Pinratana & Hämäläinen (1988) listed 85 species from the park area and 11 other species from its close surroundings. Divasiri (1993) also reported nine species of broad-winged damselflies (Calopterygoidea) and studied the larvae of *Rhinocypha* sp. and *Euphaea* sp. in this area. Three more species from the park and two from its close surroundings were reported by Hämäläinen & Pinratana (2000), thus making a total of 101 species. These species were all mapped from Nakhon Nayok or Nakhon Ratchasima provinces in the distribution atlas of Thailand's dragonflies by Hämäläinen & Pinratana (1999). Day et al. (2012) listed eight additional species from the park. The study by Saetung & Boonsoong (2016, 2019) and Rattanachan et al. (2022) also yielded the descriptions of the larvae of *Pseudagrion pruinosum, Agriocnemis minima,* and *Vestalis gracilis*. At present, 109 species of odonate have been recorded in KYNP and adjacent regions.

One of the limiting factors complicating odonate studies is the focus on the adult stage in which many species are difficult to collect, especially Anisoptera species. The large surface area of the national park and limited access via transport routes also make research in the area difficult. If these factors can be overcome, many new species records can be expected. In addition, larval collecting and rearing can be used to get information on difficult to find species (Chainthong et al. 2020; Saetung et al. 2020; Rattanachan et al. 2022; Keetapithchayakul et al. 2022; Chainthong & Boonsoong 2022). This method can fill some of the missing gaps in our knowledge of species diversity and distribution from previous works.

Methods

Sampling sites

Twenty-six sampling sites (both lotic and lentic habitats) in Khao Yai National Park and adjacent regions in the provinces of Nakhon Nayok, Prachin Buri, and Nakhon Ratchasima, Thailand, were selected (Figures 1–7, for more detail see Table 1). The map was created with ArcMap 10.3.1.

Odonate survey and collection

The survey took place during various periods: in 2019 (January, April, May, and July), 2021 (February, March, April, and November), and 2022 (March). However, due to the COVID-19 pandemic, KYNP was closed in 2020, and during the rainy season of 2021 (June to October),

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	Human disturbance
S1	Haew Suwat stream (main)*	14.44639°N 101.36500°E	lotic water	undisturbed
S2	Haew Suwat stream (branch)*	14.44639°N 101.36500°E	lotic water	undisturbed
S3	Nong Phak Chi Wildlife Watching Tower*	14.45417°N 101.35917°E	lentic water	disturbed
S4	Haew Narok stream*	14.28778°N 101.39250°E	lotic water	undisturbed
S5	Wang Jum Pee stream*	14.44639°N 101.36500°E	lotic water	undisturbed
S6	Jet Kod pond	14.49507°N 101.13915°E	lentic water	disturbed
S7	Nang rong stream	14.30588°N 101.28760°E	lotic water	undisturbed
S8	Golf pond	14.30596°N 101.28717°E	lentic water	disturbed
S9	Sao Noi stream	14.18878°N 101.52977°E	lotic water	undisturbed
S10	Kang Kho stream*	14.17670°N 101.59006°E	mixed water	disturbed
S11	Nong Khaw pond	14.10910°N 101.53241°E	lentic water	disturbed
S12	Wang Muang Waterfall*	14.23947°N 101.34393°E	lotic water	undisturbed
S13	Chao Por Khao Yai Shrine*	14.50661°N 101.38022°E	lotic water	undisturbed
S14	Chao Por Khao Keao Shrine*	14.38393°N 101.39136°E	lotic water	undisturbed
S15	Khao Keao pond*	14.48341°N 101.39064°E	lentic water	undisturbed
S16	Ban Muk Suk Sai resort	14.39036°N 101.69489°E	lentic water	disturbed
S17	Lum Pha Pleang stream	14.45508°N 101.63583°E	mixed water	disturbed
S18	Lum Pha Pleang pond	14.39844°N 101.68331°E	lentic water	disturbed
S19	Bunyarit temple	14.37977°N 101.70069°E	mixed water	disturbed
S20	Hanuman pond	14.14537°N 101.72694°E	lentic water	disturbed
S21	Phuritat resort	14.12414°N 101.70797°E	mixed water	disturbed
S22	Tha U-dom temple	14.05683°N 101.73600°E	lentic water	disturbed
S23	Agricultural pond A	14.12627°N 101.56653°E	lentic water	disturbed
S24	Agricultural pond B	14.17155°N 101.53181°E	lentic water	disturbed
S25	Tan Tip stream*	14.18139°N 101.53208°E	lotic water	undisturbed
S26	Wang Ta Krai	14.32733°N 101.30153°E	mixed water	undisturbed

which coincided with the second wave of COVID-19, the authors were not allowed to conduct surveys.

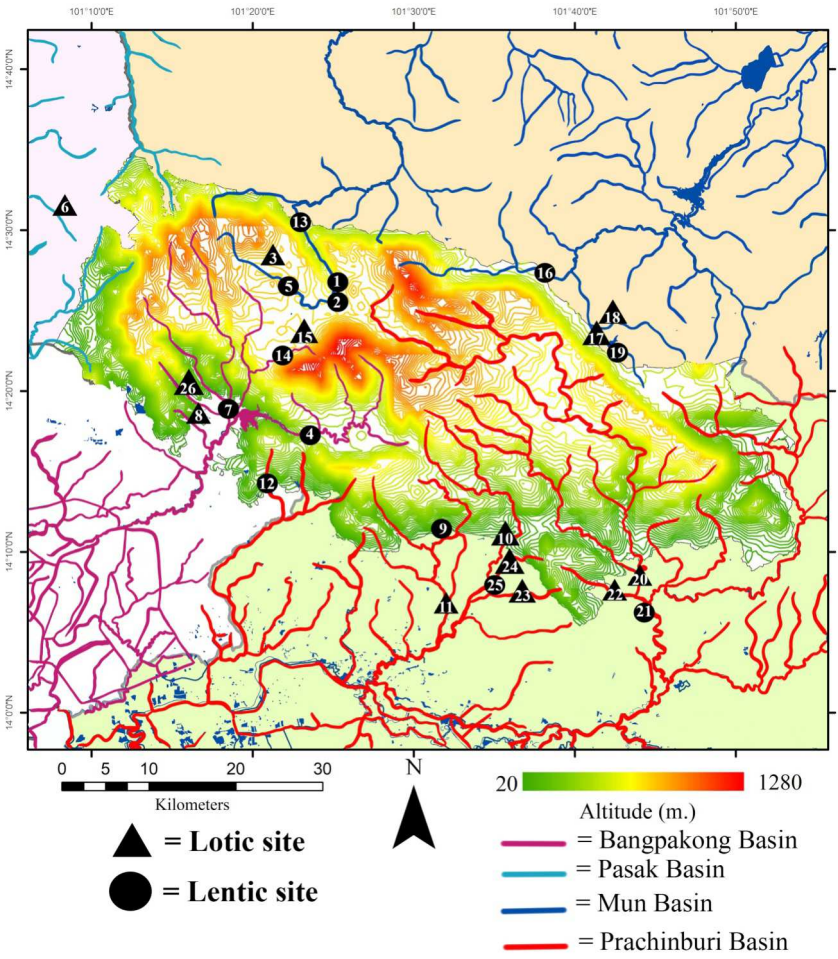

Figure 1. Map of Khao Yai National Park and adjacent regions. The Twenty-six sampling, sites number are represented in triangle (lotic sites) and circle (lentic sites).

The odonate collecting followed the methodological protocol developed by Cezário et al. (2021). Larvae were collected using D–frame nets from different microhabitats and sweep nets were used to capture adults. Fully grown larvae were taken back to the laboratory for rearing in earthenware pots (Keetapithchayakul et al. 2022; Rattanachan et al. 2022; Chainthong & Boonsoong 2022). Unsuccessfully reared larvae, exuviae, and teneral adult specimens were preserved in absolute ethanol. Adult specimens were kept in envelopes and then were steeped in 100% acetone for 6–8 hours before air drying. Photographs from the field works were also used to aid identification and used as evidences for some additional records.

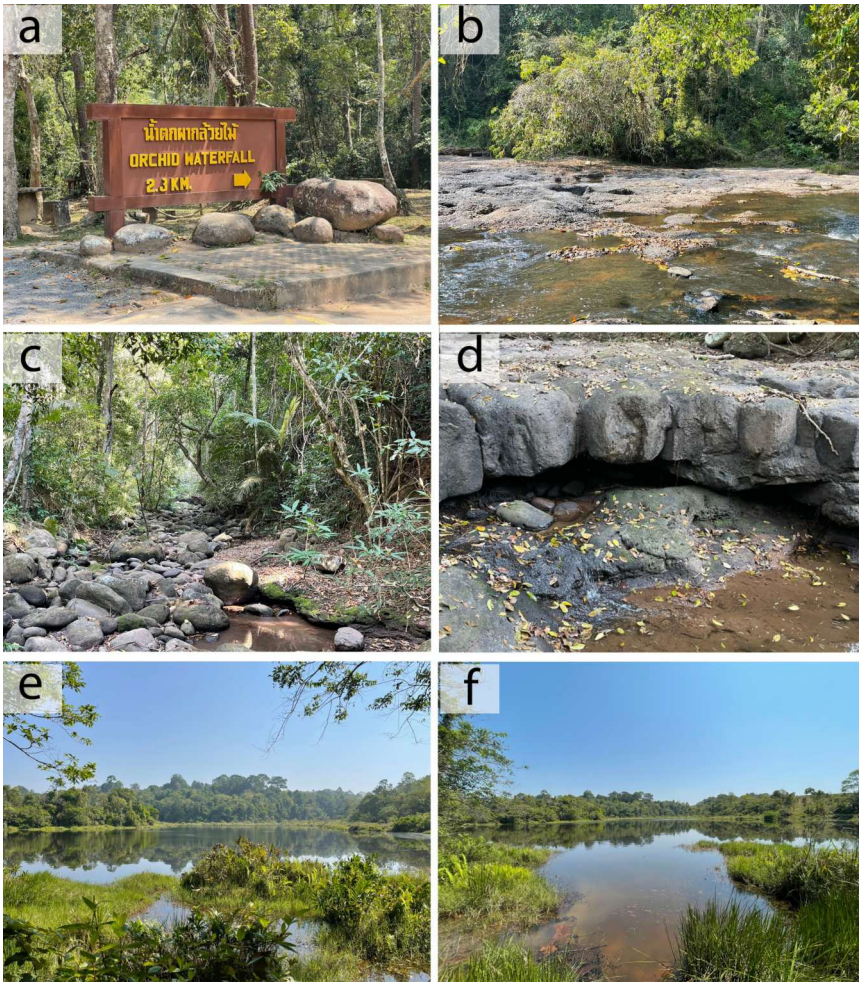

Figure 2 Sampling sites: a) Entrance of Haew Suwat stream; b) Haew Suwat stream (S1); c, d) small stream of Haew Suwat stream (S2); e, f) Nong Phak Chi Wildlife Watching Tower (S3).

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 Tosaphol Saetung Keetapithchayakul's collection.

Additionally, odonate records known from the area from other sources, the Facebook group "Dragonflies of Thailand and Noppadon Makbun's unpublished records were included in this study.

Figure 3. Sampling sites: a) Entrance of Haew Narok stream; b, c) Haew Narok stream (S4); d, e, f) Wang Jum Pee stream (S5).

Data analysis

The relationship between species composition (presence/absence data) and sampling sites were analyzed using clustering (two-way cluster analysis (TWCA) with Relative Sorensen distance measure and Group average linkage method). The correlation between odonate larvae and microhabitat were analyzed using clustering (TWCA with Correlation distance measure and Group average linkage method). These multivariate analyses were performed using PC-ORD software version 7.01 (McCune & Mefford 2011).

Figure 4. Sampling sites: a, b) Jet Kod pond (S6); c, d) Nang rong stream (S7); e, f) Golf pond (S8).

The two-way cluster analysis is a statistical method used to simultaneously cluster rows (sampling sites/microhabitats) and columns (species composition/species) of a binary presence-absence matrix. It aims to uncover patterns and associations between the rows and columns, revealing how certain rows are related to specific columns, and vice versa.

If the percentage of information remaining after clustering is higher than 75%, it indicates high similarity among the factors being analyzed (sampling sites/microhabitats or species). In this context, when factors have high similarity (more than 75%), they cannot be separated effectively into distinct cluster groups. Conversely, if the percentage of information remain-

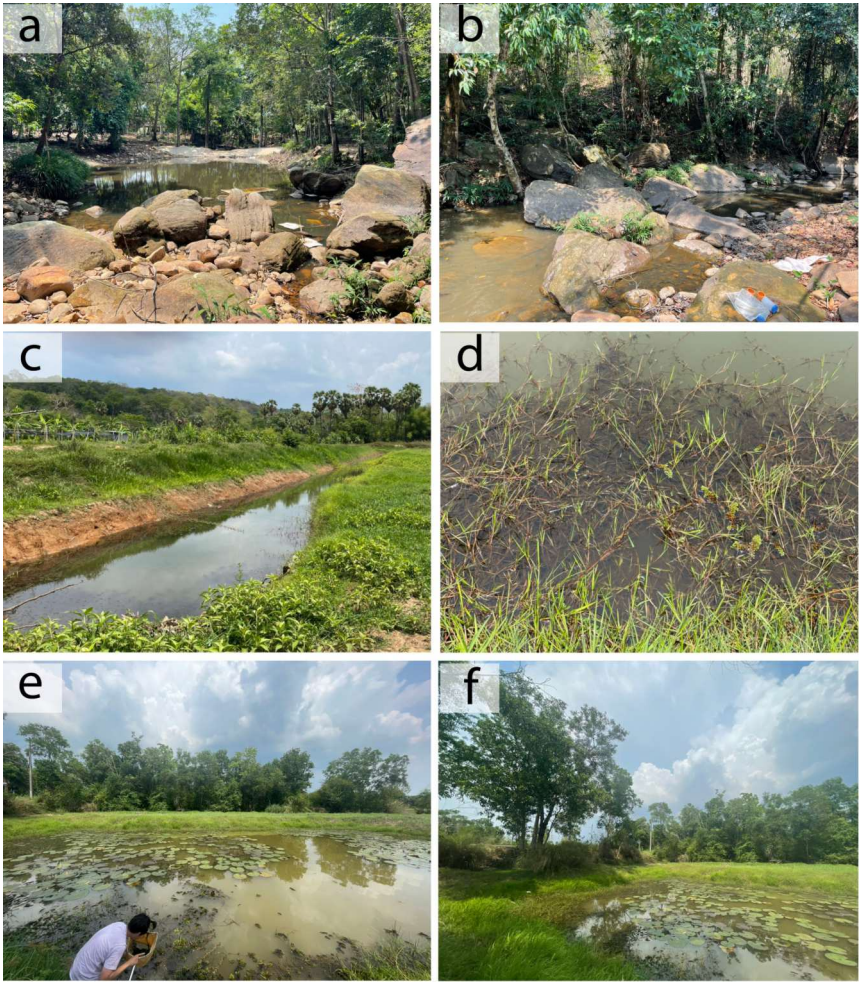

Figure 5. Sampling site: a, b) Sao Noi stream (S9); c, d) Kang Kho stream (S10), e, f) Nong Khaw pond (S11).

ing is lower than 25%, it suggests high dissimilarity among the factors. In this case, the factors can be effectively separated into distinct cluster groups (and those factors will be described as more than 75% dissimilarity between each group).

Results

A total of 78 species were found from all 26 sampling sites during our survey. The records are presented below as “observation” (records without collecting voucher specimens), “larvae”, and “adult” records (sampling of voucher specimens) (Table 2). Additional records of 39

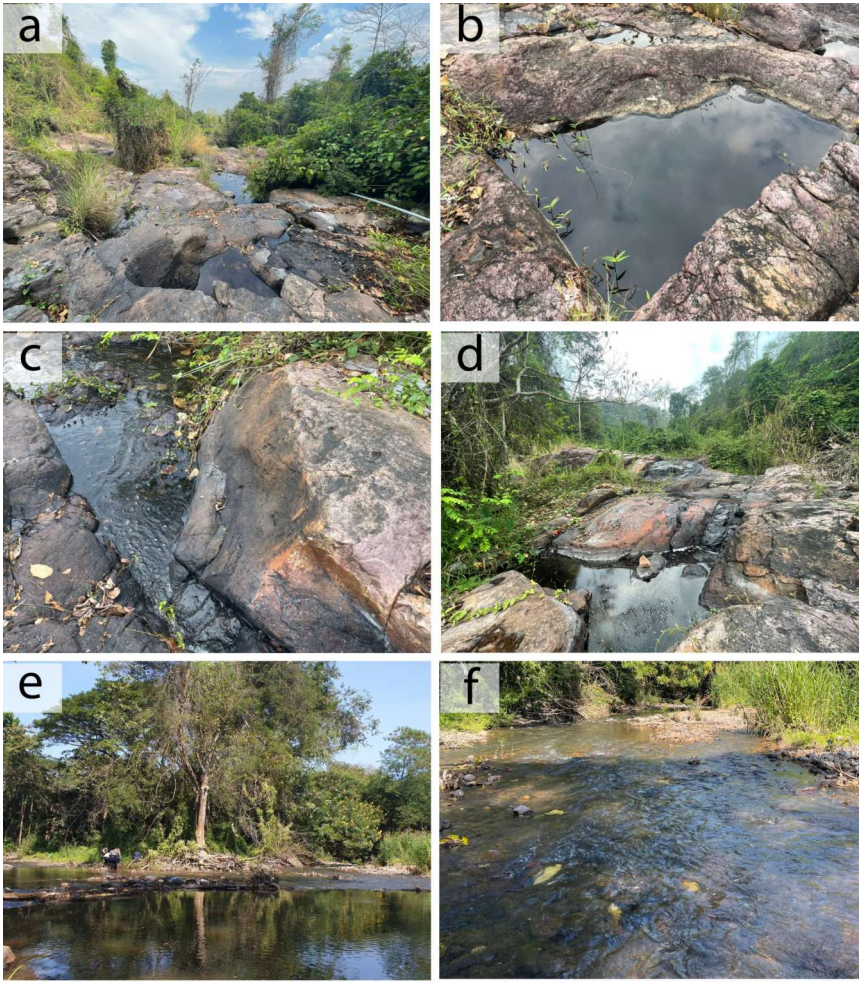

Figure 6. Sampling site: a, b, c, d) Wang Muang Waterfall (S12); e, f) Chao Por Khao Yai Shrine (S13).

species were compiled from photographic records from the Facebook page “Dragonflies of Thailand” and unpublished personal records. (Table 3). The tables 2 and 3 can be found in the appendix.

Abbreviations as follows: ESL = early stadium larvae, LSL = Last stadium larvae, RS = reared specimen, N/A = not applicable (no data record), TSK = Tosaphol Saetung Keeta-pithchayakul, NM = Noppadon Makbun, and KR = Keawpawika Rattanachan.

Figure 7. Sampling site: a, b) Chao Por Khao Keao Shrine (S14); c) Ban Muk Suk Sai resort (S16); d) Lum Pha Pleang stream (S17); e) Lum Pha Pleang pond (S18); f) Bunyarit temple (S19).

Species recorded (Figures 9–13, see appendix)

Aeshnidae

Gynacantha subinterrupta Rambur, 1842

Observation: S13, 1♂, 4.11.2021, NM.

Voucher specimen: Larval stage: S13, 3♂, 1♀, 4.11.2021, TSK leg. Adult stage: N/A

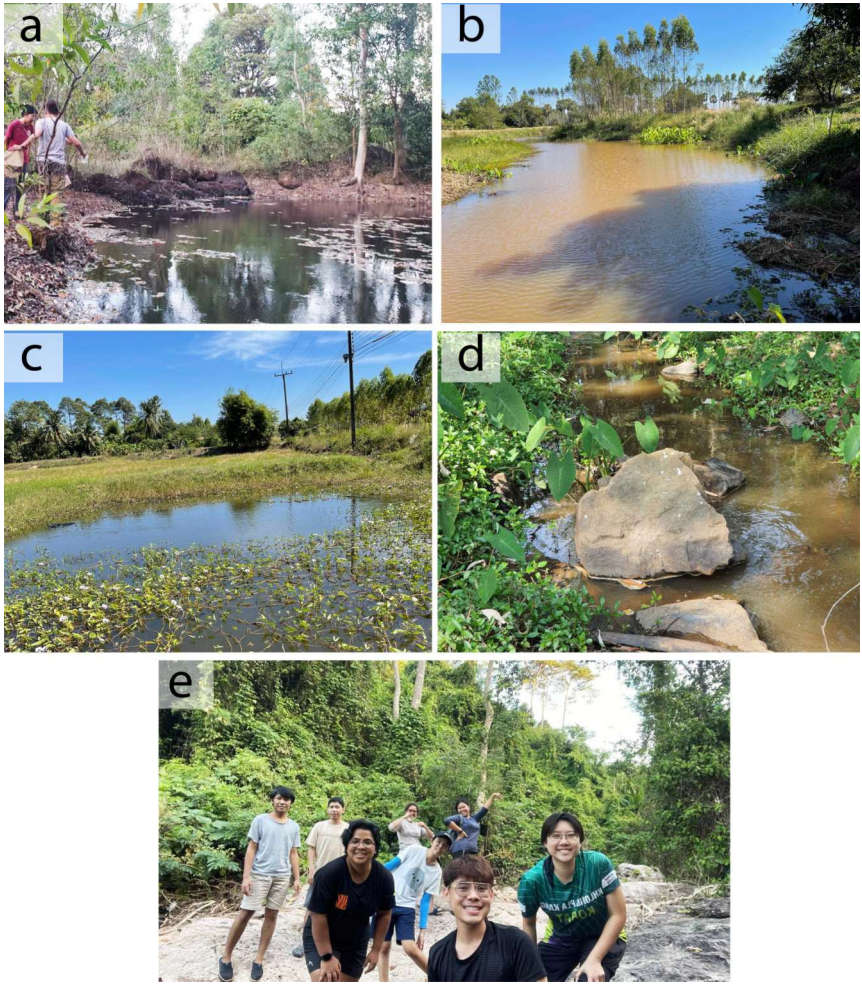

Figure 8. Sampling site and research team: a) Hanuman pond (S20); b) Tha U-dom temple (S22); c) Agricultural pond A (S23); d) Tan Tip stream (S25); e) research team - front line Tosaphol Saetung Keetapithchayakul, second line - Koraon Wongkamhaeng (left) and Patchara Danaisawadi (right), Third line - Anothai Suklom (Master degree student) and Chanikan Katnum (Master degree student), fourth line - Noppadon Makbun, Behind – Satreerat Pamkasem (Master degree student) and Dungruedee Tokongsup.

Tetracanthagyna waterhousei McLachlan, 1898

Observation: N/A

Voucher specimen: *Larval stage*: S1, 1 ESL, 17.05.2019, KR leg.; 1 LSL, 1 RS, 26.02.2021, TSK leg.; S2, 1 LSL, 26.02.2021, TSK leg.; S4, 1 ESL, 05.01.2019, KR leg.; S5, 1 LSL,

15.07.2019, KR leg.; S14, 2 LSL, 04.11.2021, TSK leg.; S17, 1 ESL, 05.11.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Gomphidae

Burmagomphus divaricatus Lieftinck, 1964

Observation: N/A

Voucher specimen: *Larval stage*: S1, 1 ESL, 3 LSL, 03.04.2019, KR leg.; S2, 1 ESL, 26.02.2021, TSK leg.; S7, 1 ESL, 1 LSL, 18.03.2021, TSK leg.; S14, 1 ESL, 04.11.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Gomphidia abbotti Williamson, 1907

Observation: N/A

Voucher specimen: *Larval stage*: S1, 2 ESL, 17.05.2019, KR leg.; S2, 1♂ RS, 26.02.2021, TSK leg.; S7, 1 ESL, 18.03.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Gomphidictinus perakensis (Laidlaw, 1902)

Observation: N/A

Voucher specimen: *Larval stage*: S1, 1 ESL, 17.05.2019, KR leg.; S2, 1 ESL, 26.02.2021, TSK leg.; S7, 1 ESL, 18.03.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Heliogomphus selysi Fraser, 1925

Observation: N/A

Voucher specimen: *Larval stage*: S14, 1 ESL, 04.11.2021, TSK leg. *Adult stage*: N/A

Ictinogomphus decoratus (Selys, 1854)

Observation: S10, 1 ESL, 09.04.2021, TSK; S11, 1 ESL, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: S2, 1 ESL, 26.02.2021, TSK leg.; S6, 1 LSL, 1 exuvia, 18.03.2021, TSK leg.; S19, 1 ESL, 05.11.2021, TSK leg. *Adult stage*: N/A

Microgomphus svihleri (Asahina, 1970)

Observation: S9, 1♂, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: S1, 1 ESL, 26.02.2021, TSK leg.; S2, 3 ESL, 26.02.2021, TSK leg.; S4, 1 ESL, 04.04.2019, KR leg.; 3 ESL, 27.02.2021, TSK leg.; S14, 1LSL, 04.11.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Orientogomphus minor (Laidlaw, 1931)

Observation: S4, 1♂, 27.02.2021, TSK.

Voucher specimen: *Larval stage*: S4, 5 ESL, 1 LSL, 27.02.2021, TSK leg. *Adult stage*: N/A

Paragomphus capricornis (Förster, 1914)

Observation: N/A

Voucher specimen: *Larval stage*: S1, 1 LSL, 26.02.2021, TSK leg.; S11, 1 LSL, 09.04.2021, TSK leg. *Adult stage*: N/A

Phaenandrogomphus asthenes Lieftinck, 1964

Observation: S4, 1♂, 27.02.2021, TSK.

Voucher specimen: *Larval stage*: S11, 1 LSL, 09.04.2021, TSK leg. *Adult stage*: N/A

Libellulidae

Acisoma panorpoides Rambur, 1842

Observation: S3, 1♂, 1♀, 27.02.2021, TSK; S6, 1♂, 18.03.2021, TSK; S8, 1♂, 18.03.2021, TSK; S10, 2♂♂ and 1♀, 09.04.2021, TSK; S11, 5 individuals, 09.04.2021, TSK; S19, 05.11.2021, NM.; S22, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S3, 1 LSL, 27.02.2021, TSK leg.; S8, 1 ESL, 1 RS, 18.03.2021, TSK leg.; S11, 1 LSL, 09.04.2021, TSK leg. *Adult stage*: N/A

Aethriamanta aethra Ris, 1912

Observation: S10, several individuals, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Aethriamanta brevipennis (Rambur, 1842)

Observation: S6, several individuals, 18.03.2021, TSK.

Voucher specimen: *Larval stage*: S3, 2 RS, 27.02.2021, TSK leg.; S6, 3 LSL, 18.03.2021, TSK leg. *Adult stage*: N/A

Brachydiplax chalybea Brauer, 1868

Observation: S17, 05.11.2021, TSK & NM; S19, 05.11.2021, NM.; S22, 06.11.2021, TSK & NM; S23, 06.11.2021, TSK & NM; S24, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Brachydiplax farinosa Krüger, 1902

Observation: S11, 3♂♂, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: S11, 1♂, 09.04.2021, TSK leg.

Brachydiplax sobrina (Rambur, 1842)

Observation: S17, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Brachythemis contaminata (Fabricius, 1793)

Observation: S6, 9 individuals, 18.03.2021, TSK; S8, several individuals, 18.03.2021, TSK; S10, 2♂♂ and 1♀♀, 09.04.2021, TSK; S11, 5 individuals, 09.04.2021, TSK; S11, 2♀♀, 09.04.2021, TSK; S20, 05.11.2021, TSK & NM; S21, 05.11.2021, TSK & NM; S23, 06.11.2021, TSK & NM; S24, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S8, several individuals, 18.03.2021, TSK leg.; S11, 2 ESL, 09.04.2021, TSK leg. *Adult stage*: N/A

Crocothemis servilia (Drury, 1773)

Observation: S21, 05.11.2021, TSK & NM; S22, 06.11.2021, TSK & NM; S23, 06.11.2021, TSK & NM; S24, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Diplacodes nebulosa (Fabricius, 1793)

Observation: S10, 1♂ and 3♀♀, 09.04.2021, TSK; S17, 05.11.2021, TSK & NM; S18, 05.11.2021, NM; S19, 05.11.2021 NM; S22, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S10, 2 LSL, 1 RS, 9.04.2021, TSK leg. *Adult stage*: N/A

Diplacodes trivialis (Rambur, 1842)

Observation: S4, 2♂♂, 27.02.2021, TSK; S8, 2♂♂, 18.03.2021, TSK; S10, 1♂, 09.04.2021, TSK; S16, 05.11.2021 TSK & NM; S17, 05.11.2021 TSK & NM; S19, 05.11.2021 NM; S22, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S16, 1 LSL, 05.11.2021 TSK leg. *Adult stage*: S4, 1♂, 27.02.2021, TSK leg.

Hydrobasileus croceus (Brauer, 1867)

Observation: S19, 05.11.2021 NM.

Voucher specimen: *Larval stage*: S3, 8 LSL, 4 RS, 27.02.2021, TSK leg.; S6, 3 LSL, 18.03.2021, TSK leg. *Adult stage*: N/A

Indothemis limbata (Selys, 1891)

Observation: N/A

Voucher specimen: *Larval stage*: N/A. *Adult stage*: S11, 1♂, 09.04.2021, TSK leg.

Neurothemis fulvia (Drury, 1773)

Observation: S7, 1♂, 18.03.2021, TSK; S9, 1♂ and 2♀♀, 09.04.2021, TSK; S11, 1♂, 09.04.2021, TSK; S19, 05.11.2021 TSK & NM; S25, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S7, 1 LSL, 18.03.2021, TSK leg.; S11, 1RS, 09.04.2021, TSK leg. *Adult stage*: S12, 1♂, 09.04.2021, TSK leg.

Neurothemis intermedia (Rambur, 1842)

Observation: S16, 05.11.2021, TSK & NM; S17, 05.11.2021, TSK & NM; S18, 05.11.2021, NM; S19, 05.11.2021, NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Neurothemis tullia (Drury, 1773)

Observation: S10, 4 individuals, 09.04.2021, TSK; S17, 05.11.2021, TSK; S18, 05.11.2021, NM; S19, 05.11.2021, NM; S22, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S17, 1 LSL, 05.11.2021, TSK leg. *Adult stage*: N/A

Onychothemis testacea Laidlaw, 1902

Observation: S7, 1♂, 18.03.2021, TSK; S13, 4.11.2021, NM.

Voucher specimen: *Larval stage*: S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Orthetrum chrysis (Selys, 1891)

Observation: S13, 1♂, 4.11.2021, NM; S17, 05.11.2021, TSK & NM; S19, 05.11.2021, NM; S22, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Orthetrum glaucum (Brauer, 1865)

Observation: S13, 1♂, 4.11.2021, NM; S19, 05.11.2021, NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Orthetrum pruinosum (Burmeister, 1839)

Observation: S1, several individuals, 26.02.2021, S13, TSK; 4.11.2021, NM; S17, 05.11.2021 TSK & NM.

Voucher specimen: *Larval stage*: S1, 3 LSL, 26.02.2021, TSK leg. *Adult stage*: S1, 1♂ and 1♀, 26.02.2021, TSK leg.

Orthetrum sabina (Drury, 1773)

Observation: S3, 1♂ and 2♀♀, 27.02.2021, TSK; S6, 2♂♂, 18.03.2021, TSK,

Voucher specimen: *Larval stage*: S3, 2 LSL, 27.02.2021, TSK leg.; S6, 1 LSL, 1 RS, 18.03.2021, TSK. *Adult stage*: N/A

Pseudothemis jorina Förster, 1904

Observation: S8, 1♂, 18.03.2021, TSK.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Pantala flavescens (Fabricius, 1798)

Observation: S19, 05.11.2021, NM.

Voucher specimen: *Larval stage*: S19, 1 LSL, 05.11.2021, TSK leg. *Adult stage*: N/A

Rhodothemis rufa (Rambur, 1842)

Observation: S19, 05.11.2021, NM.; S21, 05.11.2021, NM.

Voucher specimen: *Larval stage*: S7, 1 RS, 18.03.2021, TSK leg. *Adult stage*: N/A

Rhyothemis phyllis (Sulzer, 1776)

Observation: S6, several individuals, 18.03.2021, TSK; S8, 2♂♂ and 1♀, 18.03.2021, TSK; S10, 1♂, 09.04.2021, TSK; S23, 06.11.2021, TSK & NM; S24, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S6, 1 RS, 18.03.2021, TSK leg. *Adult stage*: N/A

Rhyothemis plutonia Selys, 1883

Observation: S6, 1♂, 18.03.2021, TSK.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Rhyothemis triangularis Kirby, 1889

Observation: S3, 8 individuals, 27.02.2021, TSK; S10, 1♂, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: S3, 1 ESL, 27.02.2021, TSK leg. *Adult stage*: S3, 2♂♂ and 1♀, 27.02.2021, TSK leg.

Rhyothemis variegata (Linnaeus, 1763)

Observation: S6, several individuals, 18.03.2021, TSK; S10, 1♀, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: S6, 2 RS, 18.03.2021, TSK. *Adult stage*: N/A

Tholymis tillarga (Fabricius, 1798)

Observation: S20, 05.11.2021, NM.; S25, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S20, 1 LSL, 05.11.2021, TSK leg. *Adult stage*: N/A

Trithemis aurora (Burmeister, 1839)

Observation: S7, several individuals, 18.03.2021, TSK; S9, 4 individuals, 09.04.2021, TSK; S13, 4.11.2021, NM.

Voucher specimen: *Larval stage*: S1, 1 ESL, 17.05.2019, KR leg.; S4, 3 ESL, 16.07.2019, KR leg.; S5, 3 LSL, 15.07.2019, KR leg.; S9, 1 RS, 09.04.2021, TSK; S12, 2♂♂, 09.04.2021, TSK; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Trithemis festiva (Rambur, 1842)

Observation: S13, 4.11.2021, NM.

Voucher specimen: *Larval stage*: S1, 1 RS, 26.02.2021, TSK leg.; S4, 1 ESL, 16.07.2019, KR leg. *Adult stage*: S1, 1♂, 26.02.2021, TSK leg.

Urothemis signata (Rambur, 1842)

Observation: S19, 05.11.2021, NM; S21, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S21, 1 LSL, 05.11.2021, TSK leg. *Adult stage*: N/A

Zygonyx iris (Selys, 1869)

Observation: S1, 1♀, 26.02.2021, TSK.

Voucher specimen: *Larval stage*: S1, 1 ESL, 17.05.2019, KR leg.; several exuviae, 26.02.2021, TSK leg.; S4, 1 ESL, 15.07.2019, KR leg.; S7, 1 ESL, 18.03.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Zyxomma petiolatum Rambur, 1842

Observation: N/A

Voucher specimen: *Larval stage*: S7, 1 RS, 18.03.2021, TSK leg. *Adult stage*: S12, 1♂, 09.04.2021, TSK leg.

Macromiidae

Macromia cupricincta Fraser, 1924

Observation: N/A

Voucher specimen: *Larval stage*: S1, 2 ESL, 17.05.2019, KR leg.; 1 LSL, 26.02.2021, TSK leg.; S9, ♂ RS, 09.04.2021, TSK leg. *Adult stage*: N/A

Synthemisidae

Idionyx thailandicus Hämäläinen, 1985

Observation: N/A

Voucher specimen: *Larval stage*: S1, 4 LSL, 26.02.2021, TSK leg.; S2, 1 ESL, 2 LSL, 1 RS, 26.02.2021, TSK leg. *Adult stage*: N/A

Macromidia genialis Laidlaw, 1923

Observation: N/A

Voucher specimen: *Larval stage*: S1, 4 LSL, 26.02.2021, TSK leg.; S2, 1 ESL, 2 LSL, 1 RS, 26.02.2021, TSK leg. *Adult stage*: N/A

Calopterygidae

Neurobasis chinensis (Linnaeus, 1758)

Observation: S1, 7 individuals, 26.02.2021, TSK; S4, 4 individuals, 27.02.2021, TSK; S7, 4 individuals, 18.03.2021, TSK; S13, several individuals, 04.11.2021 TSK & NM.

Voucher specimen: *Larval stage*: S1, 1 ESL, 26.02.2021, TSK leg.; S5, 1 LSL, 15.07.2019, KR leg.; S7, 1 ESL, 18.03.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S1, 3♂♂, 1♀, 26.02.2021, TSK leg.

Vestalis gracilis (Rambur, 1842)

Observation: S2, 2♀♀, 26.02.2021, TSK; S12, 1♂, 09.04.2021, TSK; S19, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S2, 1 ESL, 26.02.2021, TSK leg.; S5, 1 ESL, 15.07.2019, KR leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S2, 2♂♂, 1♀, 26.02.2021, TSK leg.

Chlorocyphidae

Heliocypha biforata (Selys, 1859)

Observation: S1, 15 individuals, 26.02.2021, TSK; S2, 7 individuals, 26.02.2021, TSK; S4, 2♂♂, 1♀, 27.02.2021, TSK; S7, several individuals, 18.03.2021, TSK; S9, 1♂, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: S1, 1 ESL, 04.01.2019, 4 LSL, 17.05.2019, KR leg., 3 LSL, 26.02.2021, TSK leg.; S2, 2 LSL, 26.02.2021, TSK leg.; S2, 2 LSL, 27.02.2021, TSK leg.; S4, 1 ESL, 05.01.2019, 2 ESL, 1 LSL, 04.04.2019, KR leg.; S5, 3 ESL, 1 LSL, 4.01.2019, KR leg.; S7, 1 ESL, 18.03.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S1, 5♂♂, 3♀♀, 26.02.2021, TSK leg.; S2, 4♂♂, 2♀♀, 26.02.2021, TSK leg.; S4, 1♂, 27.02.2021 TSK leg.; S13, several individuals, 04.11.2021, TSK & NM; S14, 1♂, 1♀, 04.11.2021, TSK & NM leg.

Libellago lineata (Burmeister, 1839)

Observation: S4, 4♂♂, 3♀♀, 27.02.2021, TSK; S7, 2♂♂, 1♀, 18.03.2021, TSK; S13, 04.11.2021, TSK & NM; S19, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S4, 2♂♂, 27.02.2021, TSK leg.

Coenagrionidae

Aciagrion borneense Ris, 1911

Observation: S13, 18.03.2021, NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: S2, 1♂, 26.02.2021, TSK leg.

Aciagrion pallidum Selys, 1891

Observation: S15, 04.11.2021, NM; S19, 05.11.2021, NM; S25, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S15, 1 exuvia, 04.11.2021, TSK leg. *Adult stage*: S2, 1♂, 26.02.2021, TSK leg.

Agriocnemis femina (Brauer, 1868)

Observation: S16, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S22, 1 LSL, 06.11.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Agriocnemis minima Selys, 1877

Observation: S6, 5♂♂, 1♀, 18.03.2021, TSK; S8, 4 individuals, 18.03.2021, TSK; S19, 05.11.2021, TSK & NM; S19, 05.11.2021, TSK & NM; S23, 06.11.2021, TSK & NM; S24, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S22, 2 LSL, 06.11.2021, TSK leg. *Adult stage*: S10, 1♂, 1♀, 09.04.2021, TSK leg.

Agriocnemis nana (Laidlaw, 1914)

Observation: S8, 1♂, 18.03.2021, TSK; S21, 06.11.2021, NM.

Voucher specimen: *Larval stage*: S22, 2 LSL, 06.11.2021, TSK leg. *Adult stage*: N/A

Agriocnemis pygmaea (Rambur, 1842)

Observation: S6, 2♂♂, 1♀, 18.03.2021, TSK; S11, 1♂, 2♀♀, 09.04.2021, TSK; S16, 05.11.2021, TSK & NM; S19, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S6, 2 ESL, 18.03.2021, TSK leg. *Adult stage*: S11, 1♂, 1♀, 09.04.2021, TSK.

Argiocnemis rubescens Selys, 1877

Observation: S3, 27.02.2021, TSK & NM.

Voucher specimen: *Larval stage*: S3, 1 ESL, 27.02.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Ceriagrion auranticum Fraser, 1922

Observation: S6, 1♂, 18.03.2021, TSK.

Voucher specimen: *Larval stage*: S22, 4 LSL, 06.11.2021, TSK leg. *Adult stage*: N/A

Ceriagrion chaoi Schmidt, 1964

Observation: S11, 1♂, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: N/A *Adult stage*: N/A

Remark: It is similar to those found in Singapore and Peninsular Malaysia. Males have an olive green synthorax with red mesepisternum and bright red abdomen.

Ceriagrion cerinorubellum (Brauer, 1865)

Observation: N/A

Voucher specimen: *Larval stage*: S11, 1 RS, 09.04.2021, TSK leg.; S22, 1 LSL, 06.11.2021, TSK leg. *Adult stage*: N/A

Ceriagrion olivaceum Laidlaw, 1914

Observation: S6, 4 individuals, 18.03.2021, TSK.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: N/A

Ceriagrion praetermissum Lieftinck, 1929

Observation: S6, several individuals, 18.03.2021, TSK.

Voucher specimen: *Larval stage*: S6, 42LSL, 1 RS, 18.03.2021, TSK leg. *Adult stage*: N/A

Ischnura senegalensis (Rambur, 1842)

Observation: S6, 1♂, 1♀, 18.03.2021, TSK; S6, 1♀, 18.03.2021, TSK; S10, 1♂, 1♀, 09.04.2021, TSK; S11, 3 individuals, 09.04.2021, TSK; S15, 04.11.2021, NM; S22, 06.11.2021, TSK; S23, 06.11.2021, NM; S24, 06.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S24, 1 LSL, 06.11.2021, TSK leg. *Adult stage*: N/A

Remark: Pinratana & Hämäläinen (1988) recorded both *I. senegalensis* and *I. aurora* (Brauer, 1865) from KYNP. Although *I. aurora* was not found in this study, to prevent

confusion in Table 3, "*I. aurora*" was replaced with "*I. rubilio* Selys, 1876 " based on the recent studies of Lorenzo-Carballa et al. (2022) and Futahashi & Kiysohi (2022). Both morphologically and phylogenetically showed that the mainland Asian *I. aurora*, in fact, is *I. rubilio* and the true *I. aurora* is found in Polynesia, Austro-Pacific and Oceania.

Mortonagrion aborense (Laidlaw, 1914)

Observation: S9, 1♂, 09.04.2021, TSK; S19, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: N/A. *Adult stage*: S3, 1♂, 1♀, 27.02.2021, TSK leg.

Pseudagrion australasiae Selys, 1876

Observation: N/A

Voucher specimen: *Larval stage*: S18, 2 LSL, 05.11.2021, TSK leg.; S22, 1 LSL, 06.11.2021, TSK leg. *Adult stage*: N/A

Pseudagrion microcephalum (Rambur, 1842)

Observation: S6, 1♂, 18.03.2021, TSK; S10, 1♂, 09.04.2021, TSK; S11, 1♂, 09.04.2021, TSK.

Voucher specimen: *Larval stage*: S6, 2 LSL, 18.03.2021, TSK leg. *Adult stage*: N/A

Pseudagrion pruinosum (Burmeister, 1839)

Observation: S7, 2♂♂, 1♀, 18.03.2021, TSK; S18, 05.11.2021, NM.

Voucher specimen: *Larval stage*: S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: N/A

Pseudagrion rubriceps Selys, 1876

Observation: S7, 1♂, 18.03.2021, TSK; S18, 05.11.2021, NM; S26, 1 RS, 06.03.2022, TSK leg.

Voucher specimen: *Larval stage*: S16, 1♂, 1♀, 05.11.2021, TSK leg. *Adult stage*: N/A

Euphaeidae

Euphaea masoni Selys, 1879

Observation: S1, 6 individuals, 26.02.2021, TSK; S4, 4 individuals, 27.02.2021, TSK; S13, several individuals, 04.11.2021, TSK and NM.; S14, 1♂ 04.11.2021 TSK.

Voucher specimen: *Larval stage*: S1, 1 ESL, 03.04.2019, KR leg., 2 ESL, 26.02.2021, TSK leg.; S2, 1 ESL, 26.02.2021, TSK leg.; S4, 2 ESL, 17.05.2019, KR leg.; 1 ESL, 27.02.2021, TSK leg.; S6, 2 LSL, 18.03.2021, TSK leg. S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S1, 3♂♂, 26.02.2021, TSK leg.; S2, 1♂, 26.02.2021, TSK leg.

Philosinidae

Rhinagrion viridatum Fraser, 1938

Observation: N/A

Voucher specimen: *Larval stage*: S4, 2 LSL, 1 RS, 27.02.2021, TSK leg. *Adult stage*: N/A

Platycnemididae

Coeliccia didyma (Selys, 1863)

Observation: N/A

Voucher specimen: *Larval stage*: N/A. *Adult stage*: S14, 1♂, 1♀, 04.11.2021 TSK & NM leg.

Coeliccia poungyi Fraser, 1924

Observation: N/A

Voucher specimen: *Larval stage*: S14, 1 ESL, 04.11.2021 TSK leg. *Adult stage*: S14, 1♂, 1♀, 04.11.2021 TSK leg.

Copera marginipes (Rambur, 1842)

Observation: S1, 4 individuals, 26.02.2021, TSK; S2, 2♂♂, 26.02.2021, TSK; S9, 5 individuals, 09.04.2021, TSK; S18, 05.11.2021, NM.

Voucher specimen: *Larval stage*: S1, 1 ESL, 26.02.2021, TSK leg.; S4, 2 ESL, 16.07.2019, KR leg.; S9, 2 LSL, 09.04.2021, TSK leg.; S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S2, 2 ♂♂, 26.02.2021, TSK leg.; S9, 2 ♂♂, 09.04.2021, TSK leg.; S13, 1♂, 1♀, 04.11.2021, TSK leg.; S13, 2 ♂♂, 04.11.2021, TSK leg.; S14, 1♂, 1♀, 04.11.2021 TSK & NM; S16, 1♂, 1♀ 05.11.2021 TSK & NM leg.

Copera vittata (Selys, 1863)

Observation: S2, 2♂♂, 26.02.2021, TSK; S14, 1♂, 1♀, 04.11.2021 TSK & NM;

Voucher specimen: *Larval stage*: S1, 1 ESL, 26.02.2021, TSK leg.; S2, 1 LSL, 27.02.2021, TSK leg.; S4, 2 LSL, 05.01.2019, KR leg., 3 ESL, 16.07.2019, KR leg.; 1 ESL, 27.02.2021, TSK leg.; S9, 2 LSL, 09.04.2021, TSK leg. *Adult stage*: S2, 4♂♂, 26.02.2021, TSK leg.; S3, 1♂, 27.02.2021, TSK leg.; S4, 1 ♀, 27.02.2021, TSK leg.; S9, 1 ♂, 09.04.2021, TSK leg.

Onychargia atrocyana (Selys, 1865)

Observation: S3, 5 individuals, 26.02.2021, TSK; S17, 05.11.2021, TSK; S19, 05.11.2021 TSK & NM.

Voucher specimen: *Larval stage*: S3, 1 LSL, 1 RS, 27.02.2021, TSK leg. *Adult stage*: S3, 3♂♂, 1♀, 27.02.2021, TSK leg.

Prodasineura autumnalis (Fraser, 1922)

Observation: S1, 6 individuals, 26.02.2021, TSK; S2, 7 individuals, 26.02.2021, TSK; S19, 05.11.2021 TSK & NM.

Voucher specimen: *Larval stage*: S1, 5 ESL, 3 LSL, 26.02.2021, TSK leg.; S3, 2 ESL, 27.02.2021, TSK leg.; S4, 7 ESL, 4 LSL, 27.02.2021, TSK leg.; S5, 12 ESL, 5 LSL, 03.04.2019, 2 ESL, 2 LSL, 27.02.2021, KS leg.; S9, 1 LSL, 09.04.2021, TSK leg.; S14, 1♂, 1♀, 04.11.2021 TSK leg. S26, 1 RS, 06.03.2022, TSK leg. *Adult stage*: S1, 1♂, 1♀, 26.02.2021, TSK leg.; S3, 1♂, 1♀, 27.02.2021, TSK leg.; S4, 1♂, 1♀, 27.02.2021, TSK leg.; S9, 1♂, 09.04.2021, TSK leg.

Pseudocopera ciliata (Selys, 1863)

Observation: S3, 1♂, 1♀, 27.02.2021, TSK; S6, 2♀♀, 18.03.2021, TSK; S10, 1♀, 09.04.2021, TSK; S17, 04.11.2021, TSK; S18, 05.11.2021, NM.; S19, 05.11.2021, TSK & NM.

Voucher specimen: *Larval stage*: S3, 1 LSL, 1 RS, 27.02.2021, TSK leg.; S6, 1 LSL, 18.03.2021, TSK leg. *Adult stage*: S3, 2♂♂, 2♀♀, 27.02.2021, TSK leg.

List of additional records of Odonata from KYNP and adjacent regions based on photographic and personal records (Figures 14–16, see appendix)

39 species were gathered from photographic records from the Facebook group “Dragonflies of Thailand” (32 species) and Noppadon Makbun’s personal records (7 species). The list was divided into suborder Anisoptera and Zygoptera, respectively. The family and species names were arranged in alphabetical order.

Aeshnidae

Anax guttatus (Burmeister, 1839): no date, P. Bunsrirum (Figure 14a)

Gynacantha basiguttata Selys, 1882: 23.02.2019, R. Reinthong (Figure 14b)

Gynacantha demeter Ris, 1911: 25-26.10.2019, N. Makbun

Gynacantha saltatrix Martin, 1909: 25-26.10.2019, N. Makbun

Polycanthagyna erythromelas (McLachlan, 1896):-28.05.22, A. Chotipun (Figure 14c)

Polycanthagyna ornithocephala (McLachlan, 1896): no date, A. Chotipun (Figure 14d)

Gomphidae

Burmagomphus asahinai Kosterin, Makbun & Dawwrueng, 2012*:* 18.06.2011, N. Makbun

Euthygomphus yunnanensis (Zhou & Wu, 1992): 28-07-2563, J. Sim (Figure 14e)

Macrogomphus kerri Fraser, 1932: no date, J. Sim (Figure 14f)

Merogomphus pavici Martin, 1904: xx.10.2018, R. Reinthong (Figure 14g)

Libellulidae

Agrionoptera insignis (Rambur, 1842): 04.10.2020, N. Buppachat (Figure 14h)

Amphithemis curvistyla Selys, 1891: 26-03-2014, R. Reinthong; 02.06.2021, W. Wongpan (Figure 14i)

Camacinia gigantea (Brauer, 1867): 23-24.11.2019, N. Makbun

Indothemis carnatica (Fabricius, 1798)*:* 16.06.2016, N. Makbun

Lyriothemis elegantissima Selys, 1883: 02.06.2021, W. Wongpan (Figure 14j)

Lathrecista asiatica (Fabricius, 1798): 23.02.2018, R. Reinthong (Figures14k)

Rhyothemis obsolescens Kirby, 1889: 25.04.0218, J. Sim (Figure 15a)

Sympetrum hypomelas (Selys, 1884): 06.10.2018, S. Tesring (Figure 14l)

Sympetrum thailandensis Makbun, 2023: 24.10.2018, D. Farrell (Figure 14m)

Tetrathemis platyptera Selys, 1878: 02.06.2021, W. Wongpan (Figure 14n)

Macromiidae

Epophthalmia frontalis Selys, 1871: 21.06.2019, J. Sim (Figure 14o)

Coenagrionidae

Archibasis viola Lieftinck, 1948: 10.10.2022, W. Wongpan (Figure 16a)

Aciagrion approximans (Selys, 1876): 04.12.2017, R. Reinthong (Figure 16b)

Aciagrion occidentale Laidlaw, 1919: 04.12.2017, R. Reinthong (Figure 16c)

Ceriagrion azureum (Selys, 1891): 13.09.2021, W. Wongpan (Figure 16d)
Ceriagrion calamineum Lieftinck, 1951: 26.04.2019, J. Sim (Figure 16e)
Paracercion calamorum (Ris, 1916): 02.03.2016, N. Makbun
Paracercion melanotum (Selys, 1876): 23-24.11.2019, N. Makbun
Pseudagrion williamsoni Fraser, 1922: no date, D. Farrell (Figure 16f)

Euphaeidae
Dysphaea gloriosa Fraser, 1938: 21.06.2021, J. Sim (Figure 16g)
Euphaea ochracea Selys, 1859: 23.08.2021, J. Sim (Figure 16h)

Lestidae
Indolestes anomalus Fraser, 1946: 29.08.2020, R. Reinthong; 25.10.2022, J. Sim (Figure 16i)
Indolestes birmanus (Selys, 1891): 26.04.2017, S. Tesring (Figure 16j)
Lestes dorothea Fraser, 1924: 02.06.2021, W. Wongpan (Figure 16k)
Lestes praemorsus Hagen in Selys, 1862: 17.08.2021, A. Chotipun (Figure 16l)
Orolestes octomaculatus Martin, 1902: 02.06.2021, W. Wongpan (Figure 16m)

Philosinidae
Rhinagrion hainanense Wilson & Reels, 2001: 23.02.2019, R. Reinthong; 25.11.2016 J. Sim; 10.09.2022, W. Wongpan (Figure 15b)
Platycnemididae
Coeliccia kazukoae Asahina, 1984: 26.12.2564, U. Rodprasert (Figure 16n)
Coeliccia nigrescens Laidlaw, 1931: 23.02.2019, R. Reinthong (Figure 16o)

Distribution

Spatial distribution

A total of 78 species were found at 26 sampling sites in KYNP and adjacent regions. The TWCA between odonate species composition and sampling sites was illustrated as a two-way clustering dendrogram (Figure 17). The dendrogram indicates dissimilarity between sampling sites and odonate species composition. This suggests that odonate species composition influences the attributes of each sampling site and may indicate factors that impact the distribution of odonate species in different areas. The results were identified at 100% dissimilarity threshold explained that two major clades of sampling site and odonate species composition. The sampling sites were categorized into two groups as follows:

Group 1 (lotic habitats) are streams (S1, S2, S4, S5, S7, S9, S12, S13, S14, S26). Species assigned to this group are *Neurobasis chinensis, Vestalis gracilis, Heliocypha biforata, Libellago lineata, Pseudagrion pruinosum, Euphaea masoni, Rhinagrion viridatum, Coeliccia didyma, C. poungyi, Copera vittata, Prodasineura autumnalis, Gynacantha subinterrupta, Tetracanthagyna waterhousei, Burmagomphus divaricatus, Heliogomphus selysi, Gomphidia abbotti, Gomphidictinus perakensis, Microgomphus svihleri, Orientogomphus minor, Phaenandrogomphus asthenes, Onychothemis testacea, Orthetrum chrysis, O. glaucum,*

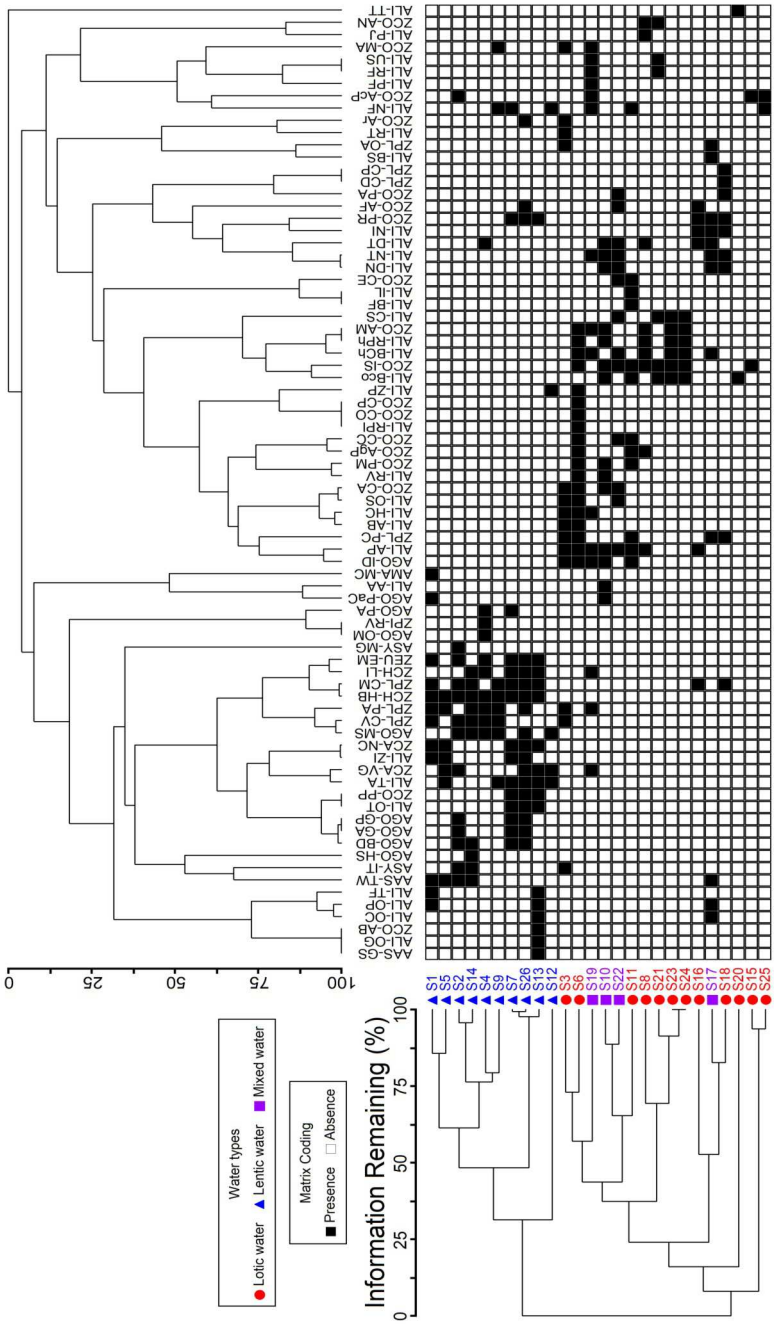

Figure 17. The two-way cluster dendrogram between odonate species composition and sampling sites. Species abbreviations refer to species list in Table 2.

*O. pruinosum, Trithemis aurora, T. festiva, Zygonyx iris, Macromia cupricincta, Idionyx thailandicu*s, and *Macromidia genialis*.

Group 2 (lentic habitats) includes a mix of habitats from ponds and streams with slow current / temporarily dried up streams (S3, S6, S8, S10, S11, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25). The odonate species belonging to this group are *Aciagrion borneense, A. pallidum, Agriocnemis minima, A. nana, A. pygmaea, Ceriagrion auranticum, C. chaoi, C. cerinorubellum, C. olivaceum, C. praetermissum, Ischnura senegalensis, Mortonagrion aborense, Pseudagrion australasiae, P. microcephalum, Onychargia atrocyana, Pseudocopera ciliata, Ictinogomphus decoratus, Acisoma panorpoides, Aethriamanta aethra, A. brevipennis, Brachythemis contaminata, Brachydiplax farinosa, B. sobrina, B. chalybea, Crocothemis servilia, Diplacodes nebulosa, D. trivialis, Hydrobasileus croceus, Indothemis limbata, Neurothemis intermedia, N. tullia, Orthetrum sabina, Pantala flavescens, Rhodothemis rufa, Rhyothemis phyllis, R. plutonia, R. triangularis, R. variegata, Tholymis tillarga, Urothemis signata*, and *Zyxomma petiolatum*.

However, five sampling sites (S10, S17, S19, S22, S26) have a stream gauge, check dam or temporarily dried up streams. These habitats are a mixture of lotic and lentic and therefore harbor both lotic and lentic odonate species (lotic species: *Copera marginipes and Pseudagrion rubriceps;* lentic species: *Agriocnemis femina, Neurothemis fulvia*, and *Pseudothemis jorina*). Generally, *A. femina, N. fulvia*, and *P. jorina* are known to oviposit in lentic water bodies such as ponds, paddy field as well as *C. marginipes* and *P. rubriceps* prefer to lay eggs around slow current habitat.

Larval habitat utilization

The result of the TWCA between microhabitats and odonate larvae of sixty-two species was demonstrated as a two-way cluster dendrogram (Figure 18). The dendrogram shows that 77% dissimilarity threshold explained identification of two distinct groups of microhabitats and odonate larvae following:

Group 1 (lotic water group) comprises two subgroups of stream microhabitats; Subgroup 1 is characterized by the availability of organic material in the habitat, such as tree roots, riparian vegetation around riffle and pool sections, algae in pools, leaf litter depositions in riffle and pool sections, and the availability of clay or mud (debris-riparian-lotic); Subgroup 2 is characterized by inorganic structures such as cobble, pebble, gravel and sand (rocky-lotic habitats). This group contains 31 species (14 species in Zygoptera and 17 species in Anisoptera). In Zygoptera, the family Platycnemididae is the most dominant with 5 species, followed by family Coenagrionidae with 3 species and families Calopterygidae, Chlorocyphidae, Coenagrionidae with 2 species each. Families Euphaeidae, and Philosinidae are the least dominant with only 1 species. In Anisoptera, Gomphidae is the most speciose family with 8 species followed by Libellulidae with 5 species, Synthemistidae with 2 species. Families Aeshnidae and Macromiidae are the least dominant with only 1 species.

Group 2 (lentic water group) aggregates in ponds with clay or mud, leaf litter, riparian vegetation, algae, and roots of trees submerged in the water. 35 species (16 Zygoptera and 19 Anisoptera) under five families were recorded in this group. In Zygoptera, 13 and 3 species belong to families Coenagrionidae and Platycnemididae, respectively. In Anisoptera, Libellulidae is the dominant family with 17 species followed by Aeshnidae and Gomphidae with one species each.

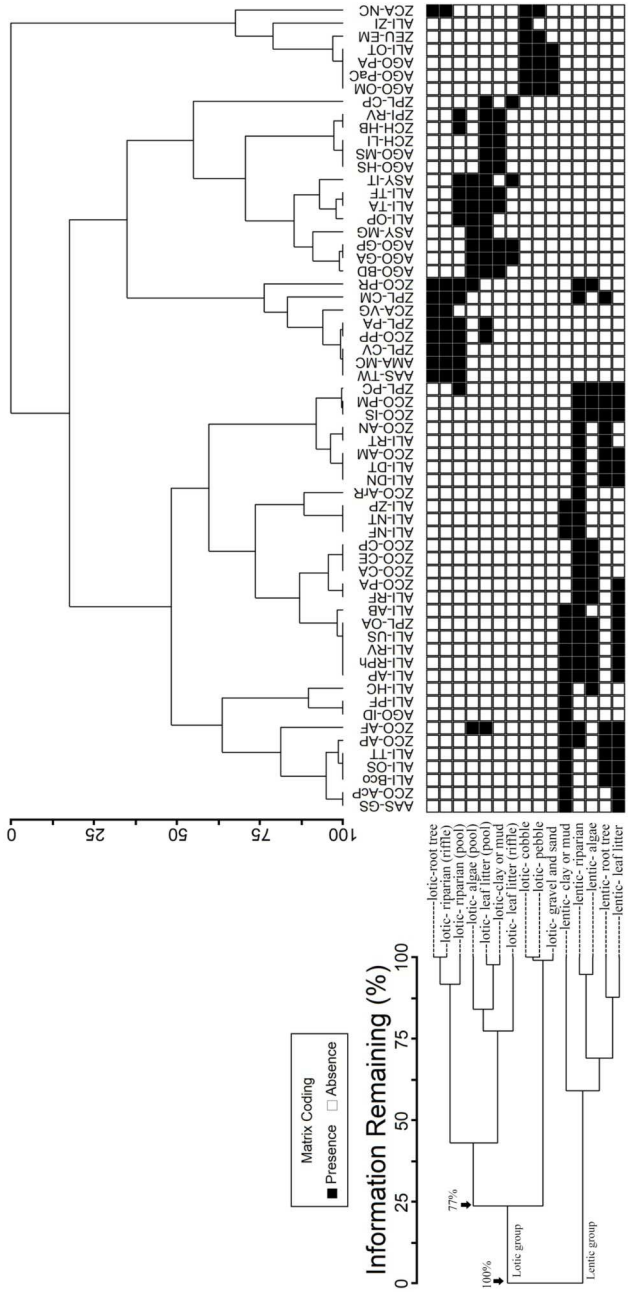

Figure 18. Two-way clustering dendrogram between microhabitats and odonate species. Species abbreviations refer to species list in Table 2.

Discussion

The updated odonate checklist of KYNP and adjacent areas brings the total number of species from 109 to 142 species, of which 33 species are new records (In addition, 115 species were found in KYNP only) (Pinratana & Hämäläinen 1988; Hämäläinen & Pinratana 2000; Day et al. 2012) (Table 3). The new records consist of 20 anisopteran species (60.6%) and 13 zygopteran species (39.4%). In the updated checklist, Libellulidae (51 species) and Coenagrionidae (28 species) are the most speciose families in suborders of Anisoptera and Zygoptera, respectively.

Comparing the number of Odonata species using larval records, adult records,

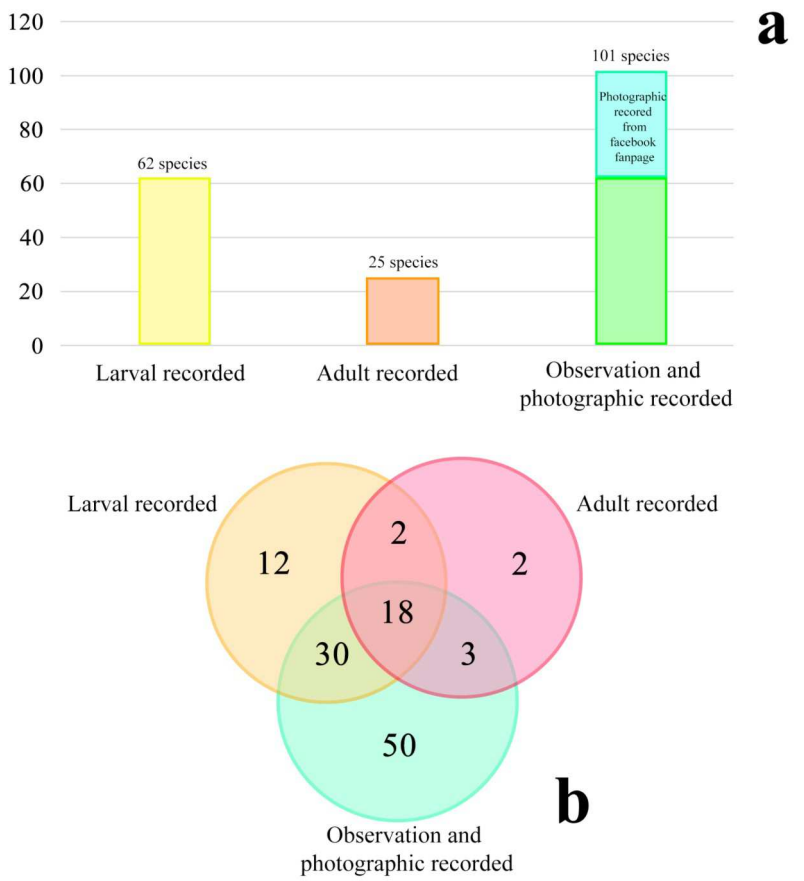

Figure 19. a) Composition of odonate species using various collected methods; b) Three cycle model indicated number of odonate species from various collected method.

and observational and photographic records provided a different number of odonate species (Figure 19). Generally, the larva records, and observational and photographic records got a higher number of species (more than 60 species) compared with adult records (25 species). Part of the reason for the low number of adult records in our study might be diel phenology factors as different foraging times and different appearance times at reproductive sites. In addition, seasonality was also a major factor since this study was carried out between the winter and summer (November-April) when the number species present as adults and species is lower compared to the rainy season when more species, especially from family Gomphidae, are known to be active. Of course, adult specimens are also necessary for the

description of new species or molecular studies (Phan et al. 2022; Makbun et al. 2022). The larval records have the advantage that a rapid–moving species or camouflaged species, especially some anisopteran species, can be caught by adequate larval sampling methods. It is also useful for collecting data on species diversity in this study since many species have different flight seasons and this study cannot compile data for all the year. The disadvantage of this method is that the larvae must be reared, and not all specimens survive to adult stage for proper identification. Unfortunately, most Southeast Asian odonate species are still unknown in larval stage, a taxonomic key is lacking, and some species are quite difficult to identify even at genus- or family-level based on the morphological characters of the larval stage. For example, the Coenagrionoidea larvae have proved problematic in terms of establishing a taxonomy which distinguishes the families Coenagrionidae and Platycnemididae, similarly with families in superfamily Libelluloidea (Steinhoff 2015; Kipping et al. 2018; Dawn & Chandra 2019; Chainthong & Boonsoong 2022). Although analyzing the species richness using observational and photographic records is a productive method, problems with taxonomic issues arise, such as misidentifications and lack of voucher specimens (Ferro et al. 2009; Day et al. 2012). However, we report here 13 new records for the KYNP based on photographic records from the Facebook group 'Dragonflies of Thailand'; all these records are properly identified. Such records enhance our knowledge on regional fauna and can encourage people to participate in local activities of citizen science (Buppachat et al. 2020).

KYNP is rich in freshwater habitats, enabling us to successfully rear more than 40 species to the adult stage. The larvae of Calopterygidae (*Neurobasis chinensis* and *Vestalis gracilis*) settle submerged roots and patches of submerged vegetation in riffles with cobbles. In particular, we found the larvae of *V. gracilis* inhabiting forest streams. They usually conceal themselves among vegetation in riffle zones and are generally found together with other calopterygid larvae such as those of *N. chinensis* (Rattanachan et al. 2022) while Kumar (1973) stated that the larvae of *N. chinensis* occur in the shallow waters of large rivers attached to submerged vegetation, and not exclusively in fast but also slow running waters.

The larvae of Chlorocyphidae and Philosinidae inhabit pools in shaded sections of forest streams or sections of rivers with slow running current. *Heliocypha perforata, Libellago lineata* and *Rhinagrion viridatum* were found sympatrically in stream pools with leaf litter as previous works have recorded (Zhang et al. 2010; Kawashima et al. 2011; Novelo-Gutiérrez et al. 2014; Xu 2015). However, larvae of two Chlorocyphidae (*H. perforata* and *L. lineata*) were also found in riffles with algae. The euphaeid larvae were found only in riffles of headwater streams. *Euphaea masoni* prefers clinging under cobbles (Keetapithchayakul et al. 2020). TSK also found euphaeid-like exuviae (with dried saccoid gills and the head is twice the width of the body, that looks like neither *Euphaea* nor *Bayadera*) on the boulder in the stream at S2. Unfortunately, that exuviae was too old and partly torn for identification. As the microhabitat of *Dysphaea* larvae probably similar to *Euphaea* and *Bayadera* (e.g., Fraser 1928; Wu et al. 2019; Keetapithchayakul et al. 2020), this is probably the exuviae of *Dysphaea* sp.

In case of Coenagrionidae (*Pseudagrion pruinosum* and *P. rubriceps*) and Platycnemididae (*Copera marginipes, C. vittata, Coeliccia poungyi* and *Prodasineura autumnalis*) larvae, we found them in submerged roots, leaf litter, and algae patches in shallow pool/riffle sections along the stream. We assessed *Pseudagrion rubriceps* and *Copera marginipes* as lotic spe-

cies, but they can adapt themselves to live in lentic habitats by attaching vegetation in sections with slower current (Saetung & Boonsoong 2016; Saetung et al. 2020). The larva of *Coeliccia poungyi* were found for the first time, in a slow riffle stream with leaf litter. The habitat agrees well with that of *C. flavostriata* Laidlaw, 1918 and *C. campioni* Laidlaw, 1918 from Sarawak, East Malaysia (Orr & Dow 2016) and *C. cyanomelas* Ris, 1912 from Fujian, China (Xu 2013). Although the number of species in genus *Coeliccia* is high in Thailand (more than ten species are known), unfortunately, none has been described in larval stage from the country.

Tetracanthagyna waterhousei and *Macromia cupricincta* are common species which can be found in headwater streams. Typically, *T. waterhousei* larvae are often found around submerged plants and tree roots and vegetation with mud as a substrate at the bank of stream (Orr et al. 2010). *Macromia cupricincta* larvae live in the slow-running part of the stream bank with submerged tree roots. The Libellulidae (*Onychothemis testacea, Orthetrum pruinosum, Trithemis aurora, T. festiva,* and *Zygonyx iris*) and Synthemistidae (*Idionyx thailandicus* and *Macromidia genialis*) larvae are assumed to be lotic species. In particular, *O. testacea* and *Z. iris* were found only in the riffle section of streams where they clung among submerged rocks. *Idionyx thailandicus, O. pruinosum, T. aurora,* and *T. festiva* were found at sections with reduced current and accumulations of leaf litter and vegetation in pools and among tree roots at the bank of streams. In case of *M. genialis* larvae, we found it under leaf litter or in algae patches in pools of the stream as described by Matsuki (1989). Nearly all Gomphidae larvae are lotic species except the members of the genus *Ictinogomphus* (Chainthong & Boonsoong 2022). They can be categorized into 2 groups (Figure 17) based on type of substrate in their microhabitat. Group A is assigned to mineral substrates (cobble, pebble, gravel, and sand) in the riffle section of streams. Species belonging to this group are *Orientogomphus minor, Paragomphus capricornis* and *Phaenandrogomphus asthenes*. The members of Group B (*Burmagomphus divaricatus, Heliogomphus selysi, Gomphidia abbotti, Gomphidictinus perakensis,* and *Microgomphus svihleri*) are found in organic or easy-to-burrow-in substrates (leaf litter, clay, or mud) in pool/riffle stretches of streams.

The stagnant waters of KYNP and the adjacent regions are dominated by lentic species of Libellulidae (*Aethriamanta brevipennis, Brachythemis contaminata, Diplacodes spp., Hydrobasileus croceus*, *Neurothemis* spp., *Orthetrum* spp., *Pantala flavescens, Rhodothemis rufa, Rhyothemis* spp., *Tholymis tillarga, Urothemis signata*, and *Zyxomma petiolatum*) and Coenagrionidae (*Aciagrion* spp., *Agriocnemis* spp., *Argiocnemis rubescens, Ceriagrion spp., Ischnura senegalensis, Mortonagrion aborense,* and *Pseudagrion* spp). The habitat preference of some species (*Agriocnemis femina, Pseudagrion microcephalum, Onychargia atrocyana, Pseudocopera ciliata, Brachythemis contaminata, Gynacantha subinterrupta, Ictinogomphus decorates*) need further observation because they can be seen in lotic habitats but obviously prefer pools or very slow running waters (Saetung & Boonsong 2019; Saetung et al. 2020). Those species can be found in many habitat types, such as flooded grasslands, natural ponds, manmade ponds, and paddy fields.

Since this study was conducted during the COVID pandemic which resulted in a severe limitation of study sites and time, there remain many unexplored areas. Further investigations at different times of the year in the studied sites and in unexplored areas are needed for a complete understanding of the diversity of Odonata at KYNP. It is very likely that there are many more species waiting for discovery including new species, and new larval de-

scriptions will surely result from further larval sampling in the area, not only in KYNP, but also in other locations throughout the Dong Phayayen–Khao Yai Forest Complex.

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Appendix

Table 2. Species list from 26 sampling sites based on observations, larva records, and adult records with water type.

No.	Code	Species	Water types
1	AAS-GS	*Gynacantha subinterrupta* Rambur, 1842	lotic water
2	AAS-TW	*Tetracanthagyna waterhousei* McLachlan, 1898	lotic water
3	AGO-BD	*Burmagomphus divaricatus* Lieftinck, 1964	lotic water
4	AGO-GA	*Gomphidia abbotti* Williamson, 1907	lotic water
5	AGO-GP	*Gomphidictinus perakensis* (Laidlaw, 1902)	lotic water
6	AGO-HS	*Heliogomphus selysi* Fraser, 1925	lotic water
7	AGO-ID	*Ictinogomphus decoratus* (Selys, 1854)	lentic water
8	AGO-MS	*Microgomphus svihleri* (Asahina, 1970)	lotic water
9	AGO-OM	*Orientogomphus minor* (Laidlaw, 1931)	lotic water
10	AGO-PaC	*Paragomphus capricornis* (Förster, 1914)	lotic water
11	AGO-PA	*Phaenandrogomphus asthenes* Lieftinck, 1964	lotic water
12	ALI-AP	*Acisoma panorpoides* Rambur, 1842	lentic water
13	ALI-AA	*Aethriamanta aethra* Ris, 1912	lentic water
14	ALI-AB	*Aethriamanta brevipennis* (Rambur, 1842)	lentic water
15	ALI-BC	*Brachydiplax farinosa* Krüger, 1902	lentic water
16	ALI-BF	*Brachydiplax sobrina* (Rambur, 1842)	lentic water
17	ALI-BS	*Brachydiplax chalybea* Brauer, 1868	lentic water
18	ALI-BC	*Brachythemis contaminata* (Fabricius, 1793)	lentic water
19	ALI-CR	*Crocothemis servilia* (Drury, 1773)	lentic water
20	ALI-DN	*Diplacodes nebulosa* (Fabricius, 1793)	lentic water
21	ALI-DT	*Diplacodes trivialis* (Rambur, 1842)	lentic water
22	ALI-HC	*Hydrobasileus croceus* (Brauer, 1867)	lentic water
23	ALI-IL	*Indothemis limbata* (Selys, 1891)	lentic water
24	ALI-NF	*Neurothemis fulvia* (Drury, 1773)	mixed
25	ALI-NI	*Neurothemis intermedia* (Rambur, 1842)	lentic water
26	ALI-NT	*Neurothemis tullia* (Drury, 1773)	lentic water
27	ALI-OT	*Onychothemis testacea* Laidlaw, 1902	lotic water
28	ALI-OC	*Orthetrum chrysis* (Selys, 1891)	lotic water
29	ALI-OG	*Orthetrum glaucum* (Brauer, 1865)	lotic water
30	ALI-OP	*Orthetrum pruinosum* (Burmeister, 1839)	lotic water
31	ALI-OS	*Orthetrum sabina* (Drury, 1773)	lentic water
32	ALI-PJ	*Pseudothemis jorina* Förster, 1904	mixed
33	ALI-PF	*Pantala flavescens* (Fabricius, 1798)	lentic water
34	ALI-RF	*Rhodothemis rufa* (Rambur, 1842)	lentic water
35	ALI-RPh	*Rhyothemis phyllis* (Sulzer, 1776)	lentic water
36	ALI-RPl	*Rhyothemis plutonia* Selys, 1883	lentic water
37	ALI-RT	*Rhyothemis triangularis* Kirby, 1889	lentic water

No.	Code	Species	Water types
38	ALI-RV	*Rhyothemis variegata* (Linnaeus, 1763)	lentic water
39	ALI-TT	*Tholymis tillarga* (Fabricius, 1798)	lentic water
40	ALI-TA	*Trithemis aurora* (Burmeister, 1839)	lotic water
41	ALI-TF	*Trithemis festiva* (Rambur, 1842)	lotic water
42	ALI-US	*Urothemis signata (*Rambur, 1842)	lentic water
43	ALI-ZI	*Zygonyx iris* (Selys, 1869)	lotic water
44	ALI-ZP	*Zyxomma petiolatum* Rambur, 1842	lentic water
45	AMA-MC	*Macromia cupricincta* Fraser, 1924	lotic water
46	ASY-IT	*Idionyx thailandicus* Hämäläinen, 1985	lotic water
47	ASY-MG	*Macromidia genialis* Laidlaw, 1923	lotic water
48	ZCA-NC	*Neurobasis chinensis* (Linnaeus, 1758)	lotic water
49	ZCA-VG	*Vestalis gracilis* (Rambur, 1842)	lotic water
50	ZCH-HB	*Heliocypha biforata* (Selys, 1859)	lotic water
51	ZCH-LI	*Libellago lineata* (Burmeister, 1839)	lotic water
52	ZCO-AB	*Aciagrion borneense* Ris, 1911	lentic water
53	ZCO-AcP	*Aciagrion pallidum* Selys, 1891	lentic water
54	ZCO-AF	*Agriocnemis femina* (Brauer, 1868)	mixed
55	ZCO-AM	*Agriocnemis minima* Selys, 1877	lentic water
56	ZCO-AN	*Agriocnemis nana* Laidlaw, 1914	lentic water
57	ZCO-AP	*Agriocnemis pygmaea* (Rambur, 1842)	lentic water
58	ZCO-AR	*Argiocnemis rubescens Selys, 1877*	lentic water
59	ZCO-CA	*Ceriagrion auranticum* Fraser, 1922	lentic water
60	ZCO-CC	*Ceriagrion chaoi* Schmidt, 1964	lentic water
61	ZCO-CE	*Ceriagrion cerinorubellum* (Brauer, 1865)	lentic water
62	ZCO-CO	*Ceriagrion olivaceum* Laidlaw, 1914	lentic water
63	ZCO-CP	*Ceriagrion praetermissum* Lieftinck, 1929	lentic water
64	ZCO-IS	*Ischnura senegalensis* (Rambur, 1842)	lentic water
65	ZCO-MA	*Mortonagrion aborense* (Laidlaw, 1914)	lentic water
66	ZCO-PA	*Pseudagrion australasiae* Selys, 1876	lentic water
67	ZCO-PM	*Pseudagrion microcephalum* (Rambur, 1842)	lentic water
68	ZCO-PP	*Pseudagrion pruinosum* (Burmeister, 1839)	lotic water
69	ZCO-PR	*Pseudagrion rubriceps* Selys, 1876	mixed
70	ZEU-EM	*Euphaea masoni* Selys, 1879	lotic water
71	ZPI-RV	*Rhinagrion viridatum* Fraser, 1938	lotic water
72	ZPL-CD	*Coeliccia didyma* (Selys, 1863)	lotic water
73	ZPL-CP	*Coeliccia poungyi* Fraser, 1924	lotic water
74	ZPL-CM	*Copera marginipes* (Rambur, 1842)	mixed
75	ZPL-CV	*Copera vittata* (Selys, 1863)	lotic water
76	ZPL-OA	*Onychargia atrocyana* Selys, 1865	lentic water
77	ZPL-PA	*Prodasineura autumnalis* (Fraser, 1922)	lotic water
78	ZPL-PC	*Pseudocopera ciliata* (Selys, 1863)	lentic water

Table 3. Checklist of species known from KYNP and adjacent regions.

X indicates that the species was recorded during this study.

O indicates that the species has been documented by a photograph in the Facebook group "Dragonflies of Thailand"

N indicates that the species has been recorded by Noppadon Makbun.

- indicates that the species has been listed in more than one of these publications: Pinratana & Hämäläinen (1988), Divasiri (1993), Hämäläinen & Pinratana (2000), and Day et al. (2012).

***** indicates that this is the first published record of this species from the area.

ü indicates that the larval stage has been described.

/ indicates that the larval stage has not been described.

KYNP indicates that this species has been recored from Khao Yai National Park sites.

AJRG indicates that this species has been recored from adjacent regions.

BOTH indicates that this species has been recored from Khao Yai National Park sites and adjacent regions.

No.	Species	Record	Larva	Location
	Suborder ANISOPTERA			
	Family Aeshnidae			
1	• *Anax guttatus* (Burmeister, 1839)	O*	ü	BOTH
2	• *Gynacantha basiguttata* Selys, 1882	O	/	KYNP
3	• *Gynacantha bayadera* Selys, 1891	-	/	KYNP
4	• *Gynacantha demeter* Ris, 1911	N*	/	KYNP
5	• *Gynacantha saltatrix* Martin, 1909	N*	/	KYNP
6	• *Gynacantha subinterrupta* Rambur, 1842	X*	ü	KYNP
7	• *Heliaeschna uninervulata* Martin, 1909	-	ü	KYNP
8	• *Polycanthagyna erythromelas* (McLachlan, 1896)	O	ü	KYNP
9	• *Polycanthagyna ornithocephala* (McLachlan, 1896)	O*	ü	KYNP
10	• *Tetracanthagyna waterhousei* McLachlan, 1898	X*	ü	BOTH
	Family Gomphidae			
11	• *Burmagomphus asahinai* Kosterin, Makbun & Dawwrueng, 2012	N*	/	AJRG
12	• *Burmagomphus divaricatus* Lieftinck, 1964	X	ü	BOTH
13	• *Euthygomphus yunnanensis* (Zhou & Wu, 1992)	O	/	AJRG
14	• *Gomphidia abbotti* Williamson, 1907	X	/	BOTH
15	• *Gomphidictinus perakensis* (Laidlaw, 1902)	X	ü	BOTH
16	• *Heliogomphus selysi* Fraser, 1925	X	ü	BOTH
17	• *Ictinogomphus decoratus* (Selys, 1854)	X	ü	BOTH
18	• *Macrogomphus kerri* Fraser, 1932	O	/	KYNP
19	• *Merogomphus pavici* Martin, 1904	O*	ü	AJRG
20	• *Microgomphus svihleri* (Asahina, 1970)	X	ü	BOTH
21	• *Nepogomphus walli* (Fraser, 1924)	-	ü	KYNP
22	• *Nychogomphus duaricus* (Fraser, 1924)	-	ü	AJRG
23	• *Orientogomphus minor* (Laidlaw, 1931)	X*	ü	KYNP
24	• *Paragomphus capricornis* (Förster, 1914)	X	ü	BOTH
25	• *Phaenandrogomphus asthenes* Lieftinck, 1964	X*	ü	BOTH
	Family Libellulidae			
26	• *Acisoma panorpoides* Rambur, 1842	X	ü	BOTH
27	• *Aethriamanta aethra* Ris, 1912	X*	/	KYNP
28	• *Aethriamanta brevipennis* (Rambur, 1842)	X	/	BOTH

No.	Species	Record	Larva	Location
29	• *Agrionoptera insignis* (Rambur, 1842)	O	ü	KYNP
30	• *Amphithemis curvistyla* Selys, 1891	O	/	KYNP
31	• *Brachydiplax chalybea* Brauer, 1868	X*	ü	AJRG
32	• *Brachydiplax farinosa* Krüger, 1902	X	/	BOTH
33	• *Brachydiplax sobrina (Rambur, 1842)*	X*	/	AJRG
34	• *Brachythemis contaminata* (Fabricius, 1793)	X	ü	BOTH
35	• *Camacinia gigantea* (Brauer, 1867)	N*	/	AJRG
36	• *Cratilla lineata* (Brauer, 1878)	-	ü	KYNP
37	• *Crocothemis servilia* (Drury, 1773)	X	ü	BOTH
38	• *Diplacodes nebulosa* (Fabricius, 1793)	X	/	BOTH
39	• *Diplacodes trivialis* (Rambur, 1842)	X	ü	BOTH
40	• *Hydrobasileus croceus* (Brauer, 1867)	X	ü	BOTH
41	• *Indothemis carnatica* (Fabricius, 1798)	N*	/	AJRG
42	• *Indothemis limbata* (Selys, 1891)	X	/	BOTH
43	• *Lathrecista asiatica* (Fabricius, 1798)	O	ü	AJRG
44	• *Lyriothemis elegantissima* Selys, 1883	O	/	KYNP
45	• *Neurothemis fluctuans* (Fabricius, 1793)	-	/	KYNP
46	• *Neurothemis fulvia* (Drury, 1773)	X	/	BOTH
47	• *Neurothemis intermedia* (Rambur, 1842)	X	ü	BOTH
48	• *Neurothemis tullia* (Drury, 1773)	X	ü	BOTH
49	• *Onychothemis testacea* Laidlaw, 1902	X	/	BOTH
50	• *Orthetrum chrysis* (Selys, 1891)	X	ü	BOTH
51	• *Orthetrum glaucum* (Brauer, 1865)	X	ü	BOTH
52	• *Orthetrum luzonicum* (Brauer, 1868)	-	ü	KYNP
53	• *Orthetrum pruinosum* (Burmeister, 1839)	X	ü	BOTH
54	• *Orthetrum sabina* (Drury, 1773)	X	ü	KYNP
55	• *Orthetrum triangulare* (Selys, 1787)	-	ü	BOTH
56	• *Palpopleura sexmaculata* (Fabricius, 1787)	-	ü	KYNP
57	• *Pantala flavescens* (Fabricius, 1798)	X	ü	BOTH
58	• *Potamarcha congener* (Rambur, 1842)	-	ü	KYNP
59	• *Pseudothemis jorina* Förster, 1904	X	/	AJRG
60	• *Rhodothemis rufa* (Rambur, 1842)	X	ü	AJRG
61	• *Rhyothemis phyllis* (Sulzer, 1776	X	ü	BOTH
62	• *Rhyothemis plutonia* Selys, 1883	X	/	BOTH
63	• *Rhyothemis obsolescens* Kirby, 1889	O*	/	KYNP
64	• *Rhyothemis triangularis* Kirby, 1889	X	/	KYNP
65	• *Rhyothemis variegata* (Linnaeus, 1763)	X	ü	BOTH
66	• *Sympetrum hypomelas* (Selys, 1884)	O*	/	KYNP
67	• *Sympetrum thailandensis* Makbun, 2023	O*	/	KYNP
68	• *Tetrathemis platyptera* Selys, 1878	O	ü	KYNP
69	• *Tholymis tillarga* (Fabricius, 1798)	X	ü	BOTH
70	• *Tramea transmarina* (Brauer, 1867)	-	ü	AJRG
71	• *Trithemis aurora* (Burmeister, 1839)	X	ü	BOTH
72	• *Trithemis festiva* (Rambur, 1842)	X	ü	KYNP
73	• *Trithemis pallidinervis* (Kirby, 1889)	-	ü	KYNP
74	• *Urothemis signata (*Rambur, 1842)	X*	ü	AJRG

No.	Species	Record	Larva	Location
75	• *Zygonyx iris* (Selys, 1869)	X	/	BOTH
76	• *Zyxomma petiolatum* Rambur, 1842	X*	ü	BOTH
	Family Macromiidae			
77	• *Epophthalmia frontalis* Selys, 1871	O	/	KYNP
78	• *Macromia callisto* Laidlaw, 1922	-	/	AJRG
79	• *Macromia chaiyaphumensis* Hämäläinen, 1986	-	/	AJRG
80	• *Macromia cupricincta* Fraser, 1924	X	/	BOTH
81	• *Macromia cydippe* Laidlaw, 1922	-	/	KYNP
82	• *Macromia septima* Martin, 1904	-	/	AJRG
	Family Synthemistidae			
83	• *Idionyx selysi* Fraser, 1926	-	ü	KYNP
84	• *Idionyx thailandicus* Hämäläinen, 1985	X	/	KYNP
85	• *Macromidia genialis* Laidlaw, 1923	X	ü	KYNP
	Suborder ZYGOPTERA			
	Family Calopterygidae			
86	• *Neurobasis chinensis* (Linnaeus, 1758)	X	ü	BOTH
87	• *Vestalis gracilis* (Rambur, 1842)	X	ü	BOTH
	Family Chlorocyphidae			
88	• *Aristocypha fenestrella* (Rambur, 1842)	-	ü	KYNP
89	• *Heliocypha biforata* (Selys, 1859)	X	ü	BOTH
90	• *Heliocypha perforata* (Percheron, 1835)	-	ü	KYNP
91	• *Libellago lineata* (Burmeister, 1839)	X	ü	BOTH
	Family Coenagrionidae			
92	• *Aciagrion approximans* (Selys, 1876)	O	/	KYNP
93	• *Aciagrion borneense* Ris, 1911	X	/	BOTH
94	• *Aciagrion occidentale* Laidlaw, 1919	O*	/	KYNP
95	• *Aciagrion pallidum* Selys, 1891	X	/	BOTH
96	• *Agriocnemis femina* (Brauer, 1868)	X	ü	BOTH
97	• *Agriocnemis minima* Selys, 1877	X	ü	BOTH
98	• *Agriocnemis nana* (Laidlaw, 1914)	X	/	BOTH
99	• *Agriocnemis pygmaea* (Rambur, 1842)	X	ü	BOTH
100	• *Archibasis oscillans* (Selys, 1877)	-	/	KYNP
101	• *Archibasis viola* Lieftinck, 1948	O*	/	AJRG
102	• *Argiocnemis rubescens* Selys, 1877	X	/	KYNP
103	• *Ceriagrion auranticum* Fraser, 1922	X*	ü	AJRG
104	• *Ceriagrion azureum* (Selys, 1891)	O*	/	BOTH
105	• *Ceriagrion cerinorubellum* (Brauer, 1865)	X	/	AJRG
106	• *Ceriagrion calamineum* Lieftinck, 1951	O	/	AJRG
107	• *Ceriagrion chaoi* Schmidt, 1964	X*	/	AJRG
108	• *Ceriagrion olivaceum* Laidlaw, 1914	X	/	KYNP
109	• *Ceriagrion praetermissum* Lieftinck, 1929	X*	/	AJRG
110	• *Ischnura rubilio* Selys, 1876 (see remark under *I. senegalensis* in the species list section)	-	ü	KYNP
111	• *Ischnura senegalensis* (Rambur, 1842)	X	ü	BOTH
112	• *Mortonagrion aborense* (Laidlaw, 1914)	X	/	AJRG

No.	Species	Record	Larva	Location
113	• *Paracercion calamorum* (Ris, 1916)	N*	/	AJRG
114	• *Paracercion melanotum* (Selys, 1876)	N*	/	AJRG
115	• *Pseudagrion australasiae* Selys, 1876	X	/	BOTH
116	• *Pseudagrion microcephalum* (Rambur, 1842)	X	ü	BOTH
117	• *Pseudagrion pruinosum* (Burmeister, 1839)	X*	ü	AJRG
118	• *Pseudagrion rubriceps* Selys, 1876	X	ü	BOTH
119	• *Pseudagrion williamsoni* Fraser, 1922	O	/	AJRG
	Family Euphaeidae			
120	• *Dysphaea gloriosa* Fraser, 1938	O	/	KYNP
121	• *Euphaea masoni* Selys, 1879	X	/	BOTH
122	• *Euphaea ochracea* Selys, 1859	O	ü	KYNP
	Family Lestidae			
123	• *Indolestes anomalus* Fraser, 1946	O*	/	KYNP
124	• *Indolestes birmanus* (Selys, 1891)	O*	/	KYNP
125	• *Lestes dorothea* Fraser, 1924	O*	/	KYNP
126	• *Lestes elatus* Hagen in Selys, 1862	-	/	KYNP
127	• *Lestes platystylus* Rambur, 1842	-	/	KYNP
128	• *Lestes praemorsus* Hagen, 1862	O	/	KYNP
129	• *Orolestes octomaculatus* Martin, 1902	O	/	KYNP
	Family Philosinidae			
130	• *Rhinagrion hainanense* Wilson & Reels, 2001	O*	ü	KYNP
131	• *Rhinagrion viridatum* Fraser, 1938	X	ü	KYNP
	Family Platycnemididae			
132	• *Coeliccia chromothorax* (Selys, 1891)	-	/	KYNP
133	• *Coeliccia didyma* (Selys, 1863)	X	/	KYNP
134	• *Coeliccia kazukoae* Asahina, 1984	O	/	KYNP
135	• *Coeliccia nigrescens* Laidlaw, 1931	O	/	KYNP
136	• *Coeliccia poungyi* Fraser, 1924	X	/	KYNP
137	• *Copera marginipes* (Rambur, 1842)	X	ü	BOTH
138	• *Copera vittata* (Selys, 1863)	X	ü	BOTH
139	• *Onychargia atrocyana* (Selys, 1865)	X	ü	BOTH
140	• *Prodasineura* sp. (nec. *verticalis* Selys, 1860)	-	/	KYNP
141	• *Prodasineura autumnalis* (Fraser, 1922)	X	ü	BOTH
142	• *Pseudocopera ciliata* (Selys, 1863)	X	ü	BOTH

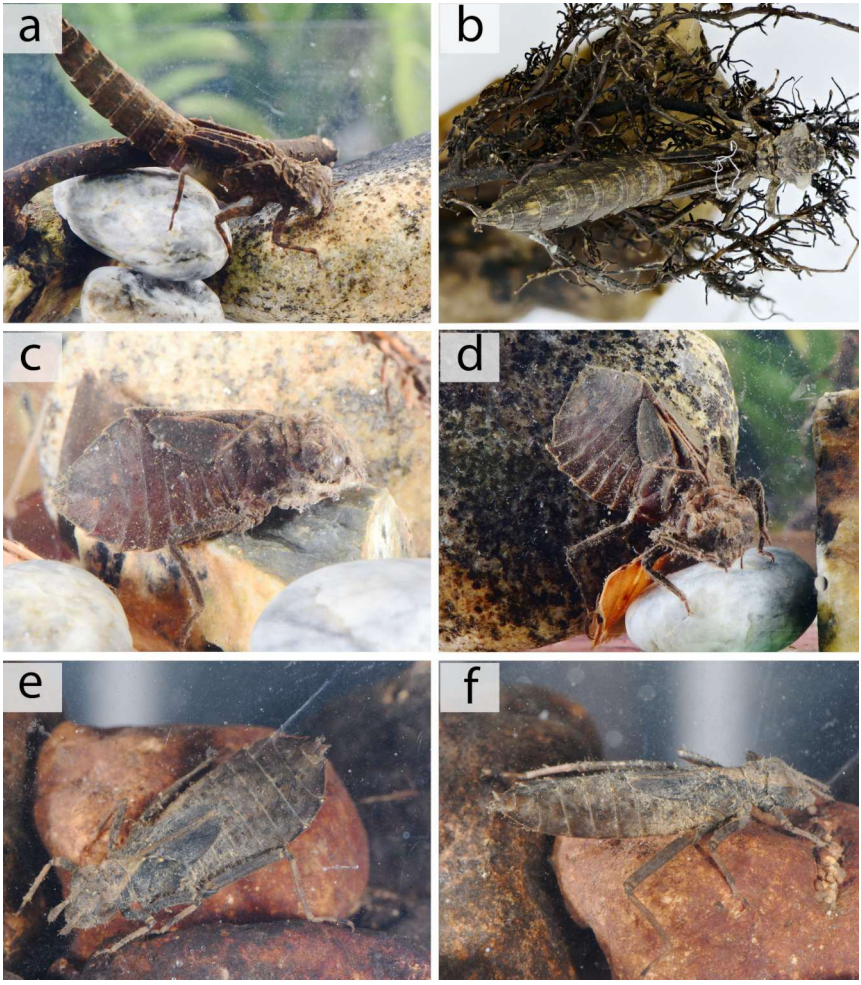


Figure 9. Photographs of larvae and exuviae: a, b) *Tetracanthagyna waterhousei*; c, d) *Gomphidia abbotti*; e, f) *Microgomphus svihleri*.

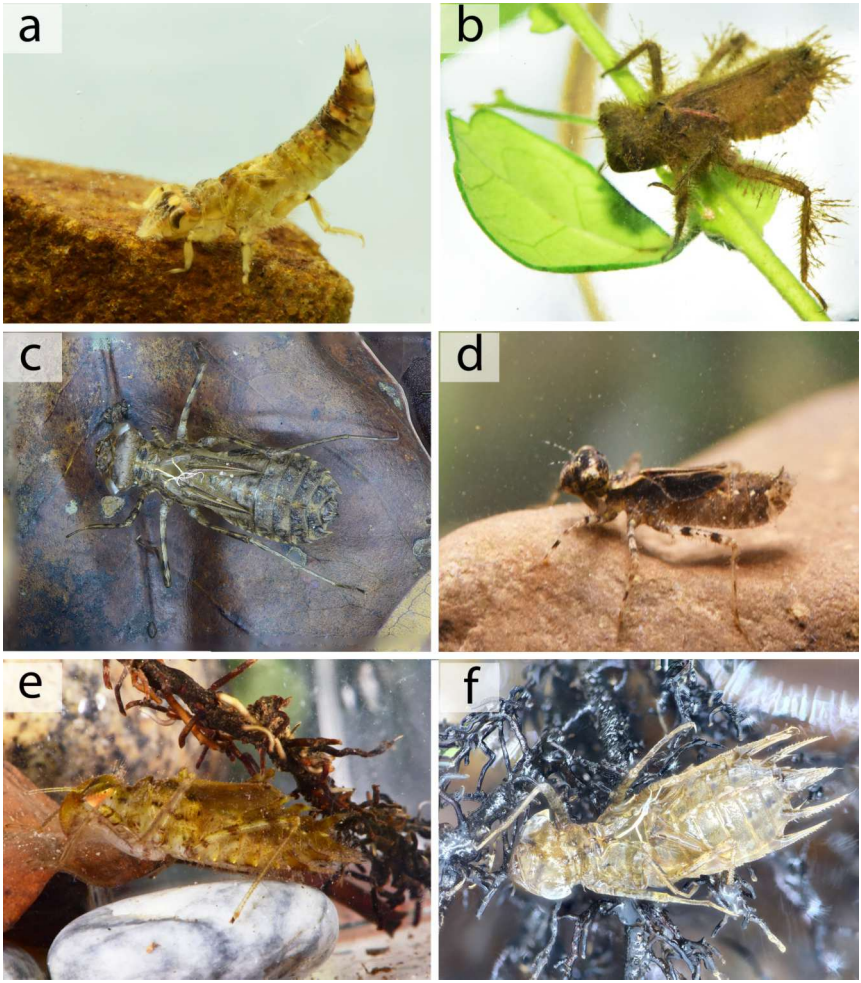


Figure 10. Photographs of larvae and exuviae: a) *Paragomphus capricornis*; b) *Acisoma panorpoides*; c) *Aethriamanta brevipennis*, d) *Diplacodes nebulosa*; e, f) *Hydrobasileus croceus*.

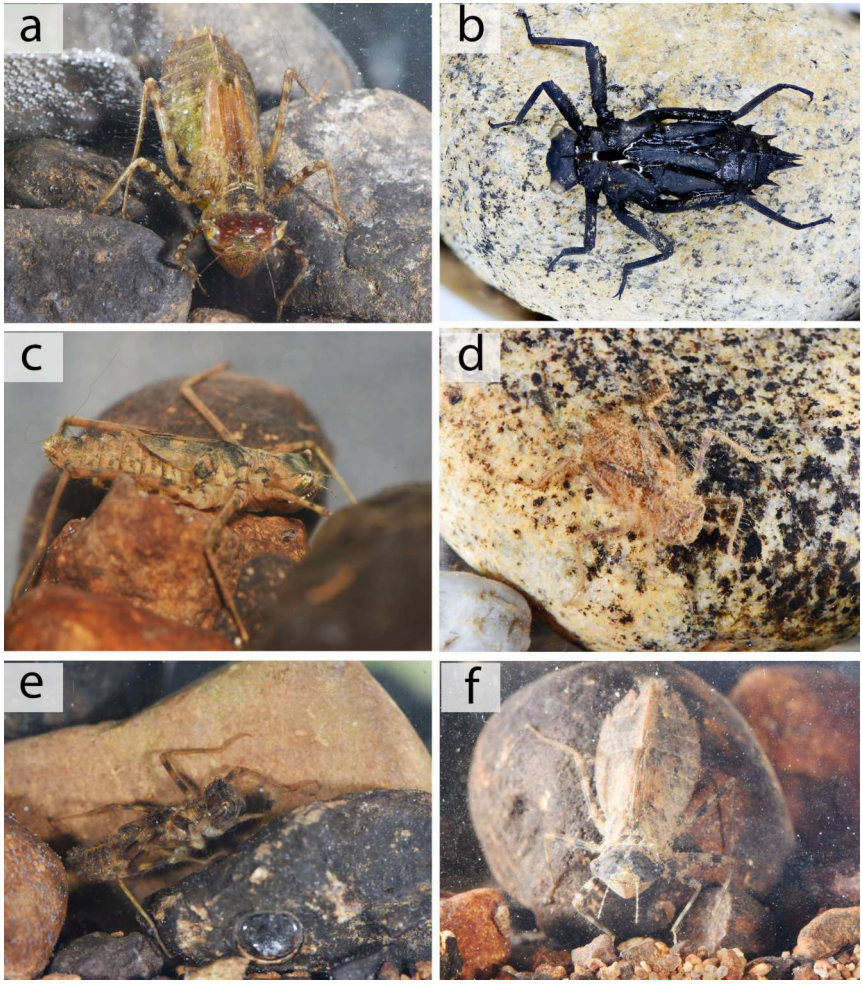


Figure 11. Photographs of larvae and exuviae: a) *Urothemis signata*; b) *Zygonyx iris*; c) *Macromia cupricincta*, d) *Idionyx* cf. *selysi*; e) *Idionyx thailandicus*, f) *Macromidia genialis*.

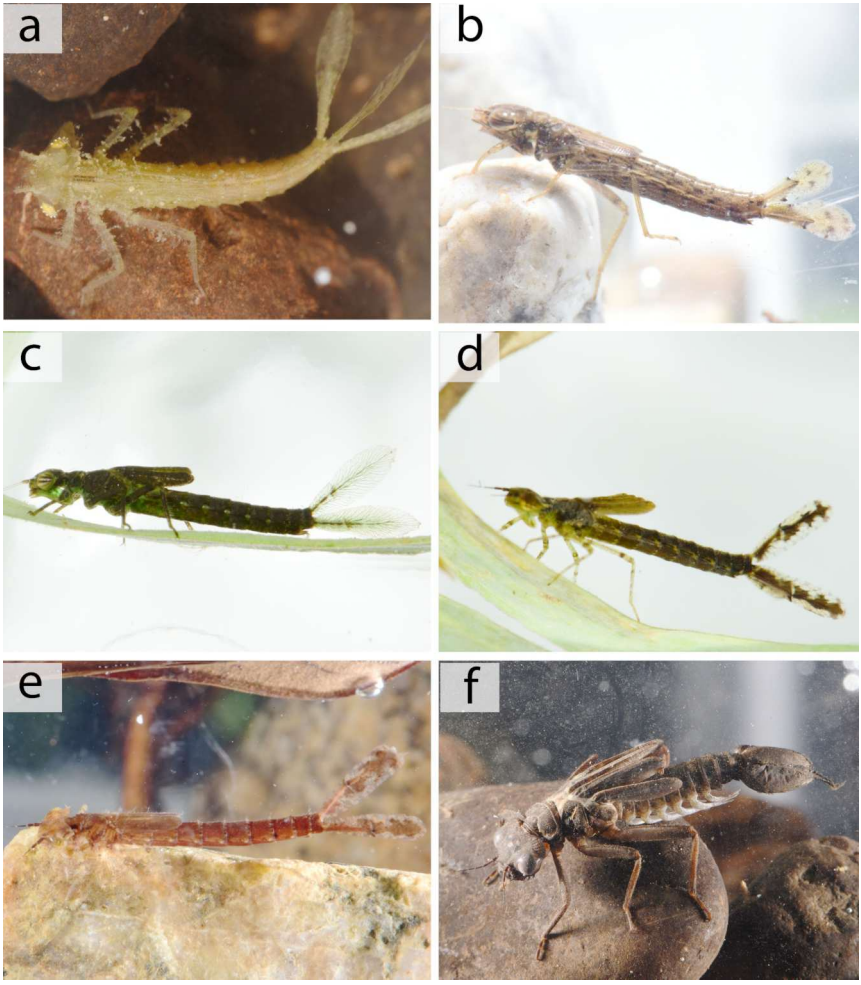


Figure 12. Photographs of larvae: a) *Agriocnemis minima*; b) *Ceriagrion auranticum*; c) *Ischnura senegalensis*, d) *Pseudagrion microcephalum*; e) *Pseudagrion rubriceps*, f) *Euphaea masoni*.

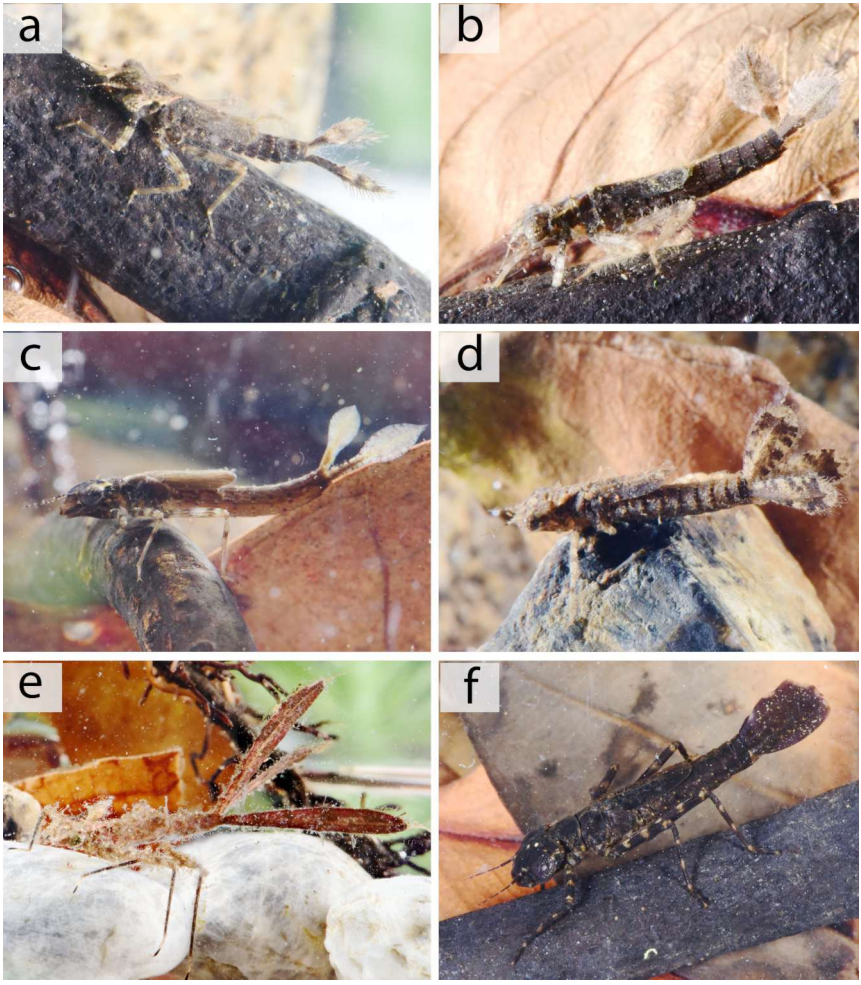
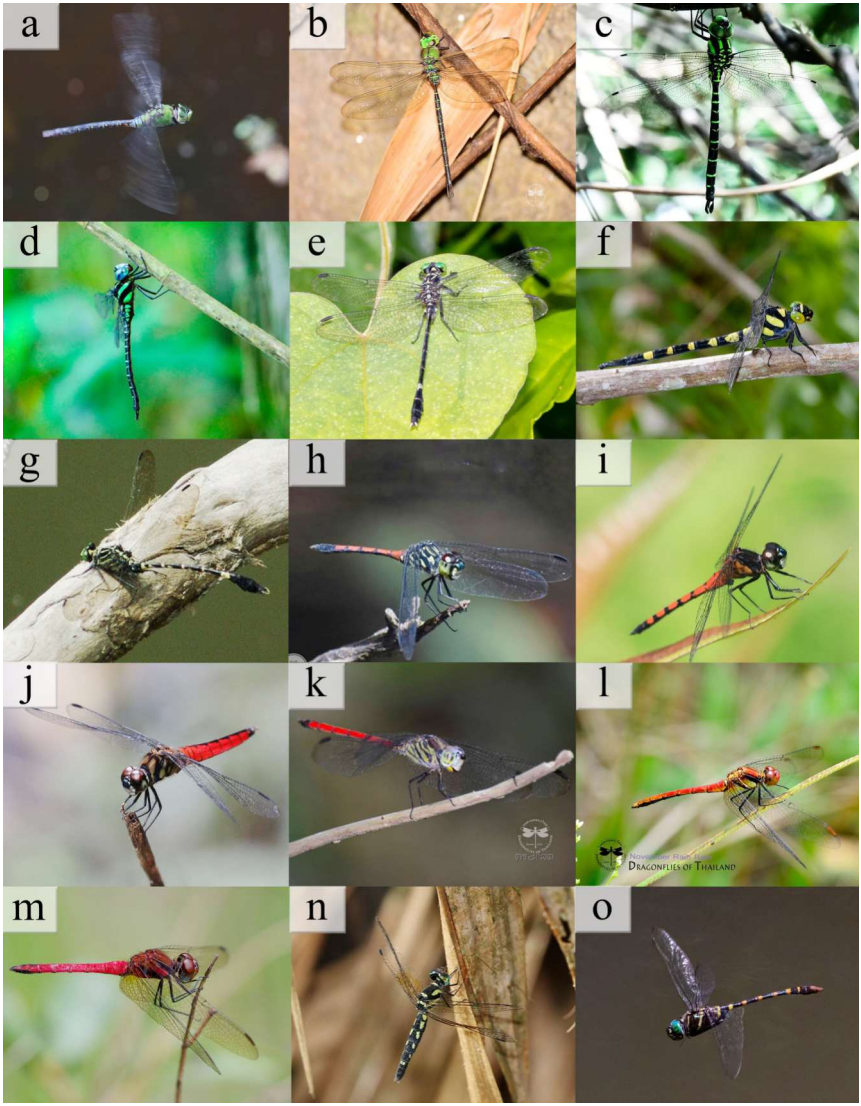


Figure 13. Photographs of larvae and exuviae: a) *Copera marginipes*; b) *Copera vittata*; c) *Onychargia atrocyana*, d) *Prodasineura autumnalis*; e) *Pseudocopera ciliata*, f) *Rhinagrion viridatum*.

Figure 14. Photographs of odonate species from the Facebook group "Dragonflies of Thailand": a) *Anax guttatus* (Photo by P. Bunsrirum); b) *Gynacantha basiguttata* (Photo by R. Reinthong); c) *Polycanthagyna erythromelas* (Photo by A. Chotipun); d) *Polycanthagyna ornithocephala* (Photo by A. Chotipun); e) *Euthygomphus yunnanensis* (Photo by J.



Sim); f) *Macrogomphus kerri* (Photo by J. Sim); g) *Merogomphus pavici* (Photo by R. Reinthong); h) *Agrionoptera insignis* (Photo by N. Buppachat); i) *Amphithemis curvistyla* (Photo by R. Reinthong); j) *Lyriothemis elegantissima* (Photo by W. Wongpan); k) *Lathrecista asiatica* (Photo by R. Reinthong); l) *Sympetrum hypomelas* (Photo by S. Tesring); m) *Sympetrum thailandensis* (Photo by D. Farrell); n) *Tetrathemis platyptera* (Photo by W. Wongpan); o) *Epophthalmia frontalis* (Photo by J. Sim).

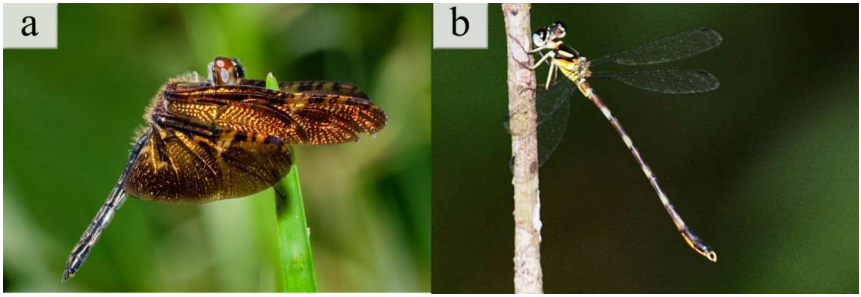
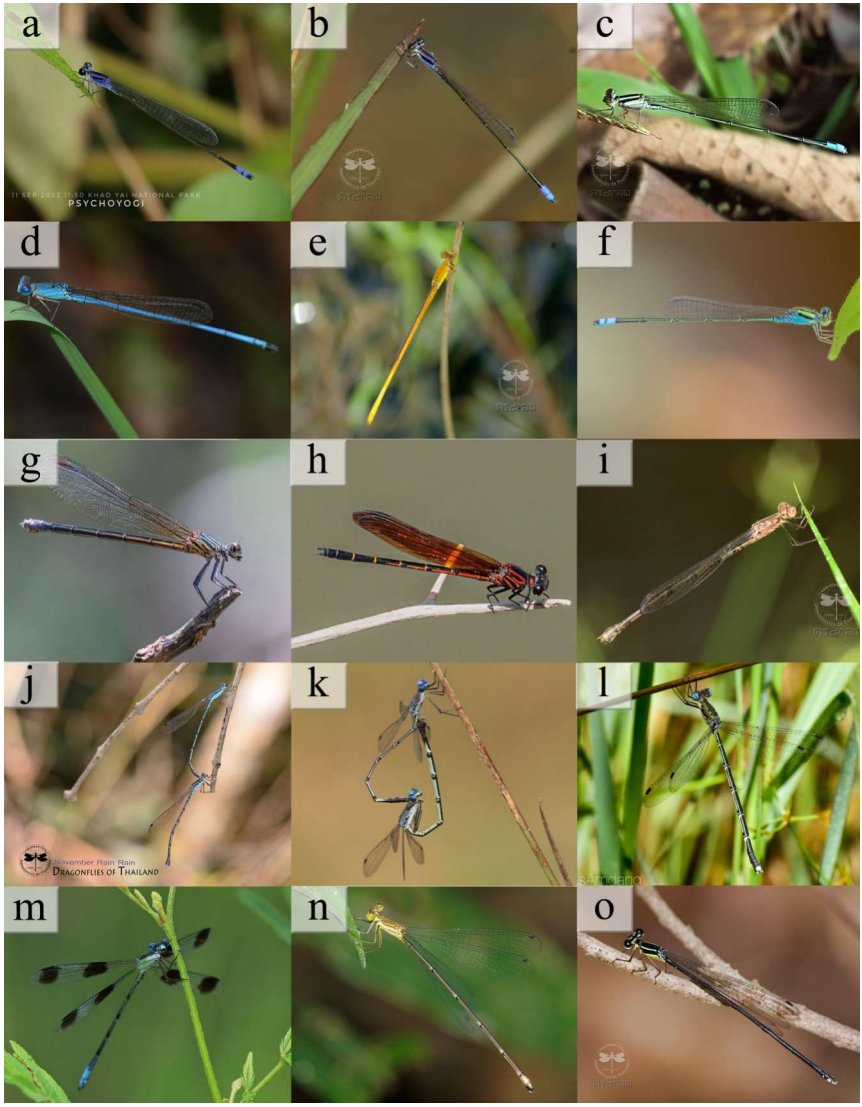


Figure 15. Photographs of odonate species from the Facebook group "Dragonflies of Thailand": (a) *Rhyothemis obsolescens* (Photo by J. Sim); (b) *Rhinagrion hainanense* (photo by R. Reinthong).

Figure 16. Photographs of odonate species from the Facebook group "Dragonflies of Thailand": a) *Archibasis viola* (Photo by W. Wongpan); (b) *Aciagrion approximans* (photo by R. Reinthong); (c) *Aciagrion occidentale* (photo by R. Reinthong); (d) *Ceriagrion azureum* (photo by W. Wongpan); e) *Ceriagrion calamineum* (photo by J. Sim); f) *Pseudagrion williamsoni* (photo by D. Farrell); g) *Euphaea ochracea* (photo by J.



Sim); h) *Dysphaea gloriosa* (photo by J. Sim); i) *Indolestes anomalus* (photo by R. Reinthong); j) *Indolestes birmanus* (photo by S. Tesring); k) *Lestes dorothea* (photo by W. Wongpan); l) *Lestes praemorsus* (photo by A. Chotipun); m) *Orolestes octomaculatus* (photo by W. Wongpan); n) *Coeliccia kazukoae* (photo by U. Rodprasert); o) *Coeliccia nigrescens* (photo by R. Reinthong).

INSTRUCTION TO AUTHORS

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Reference cited in the text should read as follows: Tillyard (1924), (Tillyard 1924), Swezey & Williams (1942).

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Swezey, O. & F. Williams, 1942. Dragonflies of Guam. Bernice P. Bishop Museum Bulletin 172: 3-6.
Tillyard, R., 1924. The dragonflies (Order Odonata) of Fiji, with special reference to a collection made by Mr. H.W. Simmonds, F.E.S., on the Island of Viti Levu. Transactions of the Entomological Society London 1923 III-IV: 305-346.

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