Rodolfo Novelo-Gutiérrez
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The Dragonfly Nymphs of Thailand (Odonata: Anisoptera)

An Identification Guide to Families and Genera

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Preface

This book is intended as a primer and first substantial effort to provide a comprehensive understanding of the Odonata nymphs of Thailand. Most of the studies devoted to this spectacular group of insects have been focused on the adults, leaving behind the knowledge of the immature stages. In many ways, this is understandable because of the charismatic nature of the adults, their apparency, and the great species richness in this tropical country. Many new species are discovered every year, and numerous nomenclatural changes have taken place in the last 25 years, since Hämäläinen and Pinratana's book "Atlas of the Dragonflies of Thailand" was published in 1999. On the other hand, an interest in the nymphs of Odonata in Thailand began just a very few years ago and is still nascent. Unfortunately, there are no resources available that bring together the widely scattered literature related to the Thai odonate nymphs, which makes it overwhelmingly difficult to begin working with this group even at the genus level. Further, there are no appropriate taxonomic keys for the local fauna, which makes accurate identification of most of the nymphs tenuous at best. For this reason, we tasked ourselves to eliminate this impediment by providing detailed descriptions, high-resolution photographs, and illustrated keys to genus level of the Anisoptera nymphs of Thailand, including distribution maps, references, and an updated list of the species recorded for this country.

Our primary motivation to prepare this book was to provide a basis from which naturalists, students, and professionals can easily and confidently identify Thai odonate nymphs to the genus level, so they will have a starting point from which to delve deeper into the fields of taxonomy, ecology, biomonitoring, and conservation involving Thai odonate nymphs. However, the reader should keep in mind that, as with all preliminary work, not all the variation in each genus has been included; thus, inconsistencies could exist in some of the descriptions and keys. Likewise, the keys are based on structures that are well or fully developed; thus, the keys are for late instars. Earlier instars might not key properly. Now that genus-level identifications are more easily possible, we hope that many enthusiastic people will take up working with Thai dragonfly nymphs; we encourage them to collect, rear, describe, and publish new findings. A more complete knowledge of the nymphs will enable us to then focus at the species level, which will in turn enable a deeper understanding of phylogenetic relationships among the taxa.

For each genus treated in this book, several montage photographs of the nymphs are provided. These photos were obtained with a Leica MZ16 stereomicroscope coupled with the Leica Application Suite V4.10 Extended Depth of Focus module, followed by image preparation with Photoshop CC2018 (Adobe Systems Inc., San Jose, California). Photographs that accompany the keys were obtained with a Nikon SMZ25 stereomicroscope (Chiyoda-ku, Tokyo, Japan) with Nikon DS-U3 camera and processed with the program NIS elements AR version 4.5 (Laboratory Imaging s.r.o., Praha, Czech Republic).

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The following colleagues and friends provided literature of the Oriental region and/or invaluable comments: Che Salmah, Klaus-D. Dijkstra, Vincent Kalkman, Matti Hämäläinen, John Mitchalski, Milen Marinov, Alonso Ramírez, Frank Suhling, Albert Orr, Gunther Fleck, Mike Ferro, Enrique González-Soriano, and Bastiaan Kiauta. Special thanks are due to Dr. Akihiko Sasamoto for the donation of nymphs and exuviae of Aeshnidae and Gomphidae as well as for providing diverse difficult-to-obtain literature. Also, thanks are due to Dr. Fang-Shuo Hu for allowing us to use his original photographs of the nymph of *Cephalaeschna risi*.

I (RNG) particularly thank Dr. Takashi Aoki (Rokko Island High School) for the exchange of Odonata larvae from Japan, which were very important for the corroboration of several generic determinations of the Thai specimens. Also, I am especially indebted to Dr. Che Salmah (Universiti Sains Malaysia) who facilitated my first contact with the amazing world of the Odonata nymphs of Southeast Asia.

Finally, we thank the editors Dr. Florian Weihrauch (Odonatologica) and Dr. John Abbott (International Journal of Odonatology) for allowing us to use several drawings published in those journals. We also thank Magnolia Press for permission to reproduce here our own photographs of *Anotogaster gregoryi*, *Amphigomphus somnuki*, and *Phaenandrogomphus tonkinicus* published previously in Zootaxa. The corrections and suggestions of four anonymous reviewers substantially improved the last version of the manuscript.

Contents

About the Authors

Rodolfo Novelo-Gutiérrez was educated at the National Autonomous University of Mexico. Following graduation at this institution, he taught general entomology courses for more than a decade. In 1989, he joined the Institute of Ecology, A.C. in Xalapa city. Since then, his studies have focused on the taxonomy of tropical Odonata, although he has also published several papers on aquatic Coleoptera, Hemiptera, and Trichoptera. In 2010, he studied odonate nymphs at the University of Sains Malaysia at the invitation of Dr. Che Salmah. From this experience, he published several papers on the odonate fauna of Southeast Asia. In 2012, he began collaborating with Prof. Sites on samples of Odonata nymphs of Thailand that had been collected over the previous 25 years.

Robert W. Sites has had extensive involvement with Thailand over the past 25 years, including in both education and research. He has taught various entomology courses to Thai students, served as major advisor for several Thai graduate students, and is known to his Thai colleagues and students as "Ajarn Bob." For nearly 20 years, he taught an annual University of Missouri study abroad course to Thailand for American students. His research on aquatic insects has been conducted in collaboration with Thai colleagues and has included field work in nearly all Thai provinces. The taxonomic focus of his studies has been primarily on Odonata and Heteroptera but also has included studies on Trichoptera and several families of aquatic Coleoptera. In an ecological study, he studied the recovery of the freshwater lentic insect community in waterbodies along the coastline that were inundated by seawater during the tsunami of 2004.

Introduction

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1.1 General

Few groups of invertebrates, other than butterflies, have captured the attention of both scientists and amateur naturalists as have the dragonflies. Their attraction to so many people is because of a myriad of reasons. They are common, colorful, and occur in many terrestrial habitats, not being restricted to areas near their nymphal aquatic habitats. They are among the most ancient winged insects, with three-foot wingspan Protodonata ancestors dating back to the Carboniferous period approximately 320 million years ago, long before dinosaurs roamed the earth. Their flight capabilities are unmatched, as they can hover, fly straight up or down, dart quickly, and stop instantly. With more than 10,000 facets per eye, their visual acuity is superb, which is one reason why they are so difficult to catch. Their biology and complex behavior are amazing considering their unique mating behavior, levels of territoriality, migrations, and more. Think about the ecological pursuit of mosquitoes as a food source in which mosquito larvae are preyed on by dragonfly nymphs in the water, and then after the mosquitoes leave the water as winged adults, the

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dragonflies are still preying on them, but now also as winged adults. In fact, adult dragonflies can eat over a hundred mosquitoes per day, and they can catch and eat them while in flight. Understandably, most people are interested in dragonfly adults for these reasons and more. However, the seldom-studied nymphs living in water also have amazing attributes worthy of attention. Because they live beneath the water surface, dragonfly nymphs are less apparent and thus have not been the subject of attention, in comparison with the adults.

Damselflies and dragonflies belong to the order Odonata (from the Greek "odonto," tooth, and "gnathos," mandibles), referring to the sharp teeth of their mouthparts. The Odonata itself dates back to the Permian period, approximately 250–280 million years ago. They have an amphibiotic life cycle with nymphs (also called *larvae* or *naiads*) being aquatic and adults terrestrial/aerial. The nymphs develop in practically any type of standing or running freshwater, although each species is highly specific to a particular aquatic habitat; some species occupy specialized microhabitats such as seepages and phytotelmata (bromeliads and tree holes filled with rain water), a few live on the vertical rock surfaces of waterfalls, some are salt-tolerant and live in brackish waters, and just a handful of species are terrestrial or semi-terrestrial. The nymphs and adults of all species around the world are voracious predators, feeding exclusively on living prey.

Adults of the closely related damselflies have a delicate, thin, slight body with both pairs of wings similar in size, shape, and venation, which is the reason they are classified into the suborder Zygoptera (Greek *zygos*, even, and *pteron*, wing). Adult dragonflies are more robust and stronger fliers than are damselflies, with both pairs of wings of different shape and venation, so they are classified into the suborder Anisoptera (Greek *anisos*, uneven, and *pteron*, wing). A third suborder, the Anisozygoptera, has three relict species of a single extant genus, *Epiophlebia*, restricted to the Indo-Oriental region, with all other representatives of this suborder extinct. The nymphs of damselflies and dragonflies also are strikingly different in morphology, most notably by the presence of three caudal gills in Zygoptera. In contrast, the nymphs of Anisoptera exhibit a short anal pyramid consisting of five acute appendages, with gills housed internally in a rectal branchial chamber.

To date, 6404 species of Odonata have been described worldwide (Paulson et al. 2023). Although the adults are quite well known, the nymphs are still poorly known, especially in the tropical regions where diversity is the highest.

1.1.1 Life Cycle

Odonata are hemimetabolous insects; thus, they have three stages of life, egg, nymph, and adult, with the first two stages developing usually in water.

Eggs: Females lay their eggs (oviposition) in a wide range of aquatic habitats, selecting sites using cues such as type and height of riparian vegetation, length of shoreline, and presence/absence of aquatic macrophytes, among others. Three modes of oviposition are used by dragonfly females: endophytic (eggs are inserted into plant tissue), epiphytic (eggs are attached to the outside of a plant), and exophytic (eggs are dropped into the water). In general, eggs deposited in the first two modes are elongate and spindle-shaped, whereas eggs laid exophytically usually are elliptical or subspherical. Eggs are laid in successive batches of 100–400 eggs in endophytic species to several hundreds to thousands per batch in exophytic species. Freshly deposited eggs usually are yellow to orange, becoming darker in a few hours. The embryos develop in a period of 7–80 days in the tropics; in temperate and cold regions, eggs may enter an obligatory diapause for overwintering, lasting several months. Eggs are vulnerable to the attack of mold, mites, predators, and parasitoids.

Nymph: After the embryo has developed, eclosion of the pronymph (first instar) takes place; the pronymph can last from a few seconds to 1–3 min, and then a rapid molting occurs to give rise to the second instar. At this point, the nymph has only three antennomeres and one tarsomere in the legs, and no wing buds are visible. The nymph continues growing by periodic moltings; the number of nymphal instars ranges from 8 to 16, completing its development in a few weeks to several years depending on the species and environmental conditions. The nymph is a voracious carnivore that behaves generally as an ambush predator. In this stage, the remarkable labium is modified to become a raptorial grabbing device, which is rapidly fired in a centesimal of a second when prey is detected, pulling the victim to the mouth to be consumed with the aid of the mandibles and maxillae. In order to avoid being preyed on themselves, they exhibit cryptic coloration while climbing among submerged vegetation, clinging to underwater objects, burrowing in the substrate, covering themselves with mud, sand, or debris, or employing jet propulsion.

At the end of the nymphal stage, the fully grown nymph stops feeding, and an internal metamorphosis occurs. The pharate adult features are visible through the nymphal cuticle, indicating the nymph is ready to climb up emergent vegetation or a rock where the final molt will occur. The newly emerged, teneral adult must wait before it can fly. During this time, it is vulnerable to predation since it is not capable of much evasive movement; thus, eclosion to the adult stage usually occurs at night. By morning, it is sufficiently sclerotized and ready for its maiden flight. In some groups (e.g., Gomphidae), emergence can occur in the morning or at noon.

Adult: Newly emerged adults fly away from the emergence site, and their cuticle continues to harden as they feed. Male and female juvenile adults exhibit similar coloration and lustrous wings. The maturation period may last from a few weeks to several months. When mature, males are usually more colorful than are females. Colors and patterns in the wings and body may play an important role in territoriality and courtship. At this time, they are sexually mature and ready for reproduction, which takes place usually near waterbodies. Males of some species hold territories near the water and defend them aggressively against conspecific males, and patrol in search of females. When a female arrives looking for a mate or attempting to oviposit, she is quickly seized by a male and copulation takes place. One mating provides enough sperm to fertilize several batches of eggs. Afterward, the female will attempt to oviposit while under the guard of the male, either in tandem or without contact with the male.

1.1.2 Importance in Food Webs

Odonates are one of the most dominant and important groups of invertebrate predators. Both nymphs and adults have important roles in natural population control of other macroinvertebrates, while at the same time serving as food for other animals, contributing to food web complexity. Adult odonates feed on mosquitoes, midges, small butterflies, moths, bees, and other odonates; some members of Coenagrionidae (e.g., Pseudostigmatinae) and Aeshnidae (e.g., *Aeschnophlebia longistigma*) are specialized in consuming web-making spiders. In contrast, adult odonates are frequently preyed upon by other invertebrates such as robber flies (Asilidae), spiders, larger odonates, and by some vertebrates such as frogs and birds. Also, they are attacked by external parasites such as gnats (Ceratopogonidae) and mites (Arrenuridae), as well as some internal parasites as viruses (Circoviridae) (Rosario et al. 2011). In the same way, odonate nymphs capture many kinds of small invertebrates such as mosquito larvae or even other odonate nymphs; large odonate nymphs can prey on tadpoles and small fish. They also serve as prey for other animals such as giant water bugs, saucer bugs, shrimp, fish, turtles, and even young crocodiles.

Odonates provide a significant service to humans and their domestic animals by consuming harmful insects that can act as vectors of pathogens such as blood-sucking flies, or insect pests that attack crops in agroecosystems.

1.1.3 Conservation

Natural aquatic ecosystems are complex and exposed to a wide variety of simultaneous stressors with cumulative effects. In recent times, habitat destruction and fragmentation have increased to alarming levels, threatening many sensitive species that require a certain amount of habitat integrity and good water quality to maintain breeding populations. In addition, recent climate change and desiccation, as well as the use of pesticides such as neonicotinoids in developing countries, may further exacerbate the situation.

Several studies have demonstrated the value of using odonate communities or assemblages as indicators of ecosystem integrity, especially in riparian corridors. Degraded habitats tend to maintain a community of very common, generalist, and widely distributed odonate species, whereas well-preserved areas sustain a more diverse community with many specialized odonate species.

The great diversity of Odonata is found in the tropical areas of the world, with much of its biodiversity still unknown to us. It is precisely in these areas where the more intensive and irrational human impacts are destroying the most fragile ecosystems. Thus, it is necessary to highlight the importance of habitat conservation to avoid the loss of more aquatic habitats, and consequently the extinction of species. It is also necessary to raise awareness among politicians, resource managers, and other decision makers before we arrive at the point of environmental no-return, after which communities cannot rebound or be recovered.

1.2 Study Area

The Kingdom of Thailand is a special country for many reasons. It has some of the most spectacular scenery, delicious food, rich culture, friendly people, and exotic biota. It is not surprising that nearly 18% of the country's GDP is from services associated with tourism. Thailand is situated in Southeast Asia and borders Myanmar, Cambodia, Laos, and Malaysia. The coastlines are over 3000 km in length and border the Andaman Sea to the west and the Gulf of Thailand to the east. At 513,120 square kilometers, Thailand is 25% larger in landmass than California in the United States and slightly smaller than France. The country is divided into six regions (Northern, Western, Northeast, Central, Eastern, and Southern) and 77 political units as provinces (Fig. 1.1).

Thailand was known as Siam until 1939, when the name was changed to reflect that it had never been brought under control by any of the European colonizing countries; Thailand means land of the free. Cambodia, Laos, and Vietnam were colonized by France; Myanmar, Malaysia, and Singapore by Britain. Thailand is the only Southeast Asian country to remain independent during the European colonial period.

A chain of mountains extends along the western border of the country from the north near Chiang Rai and Mae Hong Son south to Malaysia (Fig. 1.2). The mountains are higher and more extensive throughout the north and become lower and less continuous southward. Doi Inthanon in Chiang Mai Province is the highest mountain in the country at 2565 m elevation, and only nine other mountains exceed 2000 m, all in the north. Smaller mountain ranges, some of which are isolated, occur in the east near Sakhon Nakhon and southeast near Nakhon Ratchasima and Chantaburi. Most of eastern Thailand is flat and used for agriculture.

Being a tropical country, Thailand experiences a great amount of precipitation, but rainfall varies depending on region and time of year. The Southwest Monsoon is responsible for the rainy season; it brings moisture from the Indian Ocean northeasterly to most parts of Thailand and generally lasts from May to October. In contrast, the Northeast Monsoon passes southwesterly over China, Vietnam, and Laos, where most of its rain falls; thus, by the time this monsoon reaches Thailand from November to March, the air is relatively dry. Just as rainfall amounts vary among regions and time of year, so do temperatures. In general, the lowest temperatures occur in December and January and the highest in April and May. It might seem counterintuitive, but the best collecting for odonate nymphs and other aquatic insects is toward the end of the dry season because the water levels are lower and the insects are able to organize to their preferred habitats in the absence of scouring floods. Also, drier conditions enable easier and safer access to waterbodies.

Agriculture represents 8–10% of Thailand's GDP. Thailand is the world's biggest rice producer and exporter. This is the predominant crop in the lower flat regions, including the Korat Plateau where the fragrant jasmine rice is produced. Other major crops in Thailand include rubber, sugarcane, corn, cassava, and tree fruits. Rubber production can have a detrimental effect on aquatic insect communities because in the post-harvest treatment of rubber, sulfuric acid is used to coagulate the latex. In some unscrupulous operations, the used acid is discarded in streams, which obviously has catastrophic effects on the environment and biota.

Approximately 70 million people live in Thailand with most people in rural areas, and specifically in the rice-growing areas in the northern half of the country. Most of those who live in urban areas are concentrated in Bangkok and the surrounding area. As with most developing countries and with so many people living in rural areas, conflict with a host of environmental concerns is inevitable. In 1961, 53% of Thailand was covered by forests, whereas today that number is 31%. Despite the 1989 logging ban, tree poaching continues to occur, including within national parks and other protected areas. Rural farmers also burn the forest undergrowth in the dry season to remove old vegetation ostensibly to make way for new growth. This practice results in a myriad of detrimental effects, including widespread air pollution, the loss of forest nutrients, and it denudes the forest floor of vegetation, which exacerbates flooding. Deforestation and burning result in the predictable problems of soil erosion, sedimentation in rivers, and associated loss of habitat and biota. An estimate 36 years ago reported that 47 million tons of sediment, mostly eroded topsoil, was carried by Thai rivers annually into the Gulf of Thailand (Arbhabhirama et al. 1988). Further affecting aquatic insect communities is that coastal wetlands and mangroves have been impacted by the construction of a dramatic number of unsustainable commercial shrimp ponds. The ponds have a relatively short life span because of disease and a gradual reduction in productivity, after which the pond is relocated to a newly cleared area of coastline.

Thailand is perhaps more proactive about conservation efforts than most other developing countries. Single species conservation programs are in place that focus on protection for elephants, tigers, clouded leopards, and other species of the charismatic megafauna. Broader conservation programs protect entire ecosystems, including mangroves, coral reefs, and forests. Although laws are in place for protection, penalties can be light and enforcement negligible.

Two major river systems drain most of the country. The Mekong River and associated tributaries drain the eastern part of Thailand toward the southeast and empty into the South China Sea. Most of the land included in this watershed are lowlands, including the Korat Plateau. The Chao Phraya River watershed is the largest in Thailand and includes approximately one third of the country, draining the mountains in the north toward Bangkok and emptying into the Gulf of Thailand. In addition to these lotic systems, numerous standing waterbodies occur throughout the landscape, from small roadside ponds and check-dam ponds to larger wetlands, reservoirs, and lakes.

South of Bangkok is the Isthmus of Kra, which is a narrow neck of land only 40 km wide in Chumphon Province. It separates the Andaman Sea in the west from the Gulf of Thailand to the east. The isthmus also presents a limit to distribution for certain biota, with some taxa on one side or the other, occurring either in the Sundaic zoogeographic region to the south, or the Indochinese region to the north. Most of the biogeographic work has involved mammals, birds, and plants, although a few investigations have considered insects, arachnids, and prawns.

Faunistic studies of Thai aquatic insect taxa have spanned many of the major groups. Most recently, the Trichoptera have been studied by Porntip Chantaramongkol and her many students in Chiang Mai (e.g., Malicky and Chantaramongkol 1999), Ephemeroptera (e.g., Sites et al. 2001; Boonsoong and Braasch 2010; Tungpairojwong and Boonsoong 2011; Boonsoong and Sartori 2016; Auychinda et al. 2020; Boonsoong 2022), several families of Coleoptera by William Shepard (e.g., Shepard and Sites 2016, 2019), Diptera (e.g., Rattanarithikul and Panthusiri 1994; Cranston 2007; Plant et al. 2011), and Heteroptera (e.g., Sites and Vitheepradit 2011). Although a sizable literature exists for Odonata, this predominantly treats adults (e.g., Pinratana et al. 1988; Asahina 1993; Hämäläinen and Pinratana 1999, 2000; Hämäläinen 2002; Yeh 1999; Pinratana 2003; Kitagawa and Katatani 2002, 2003, 2005; Katatani et al. 2004; Katatani et al. 2010; Thipaksorn et al. 2003; Ferro et al. 2009; Kosterin and Vikhrev 2009; Kosterin et al. 2012; Sasamoto 2015; Yanagisawa and Sasamoto 2017; Makbun 2017a, b, 2022; Sribal et al. 2018; Farrell and Makbun 2020; Pierce and Makbun 2020; Buppachat et al. 2020; Kompier et al. 2021) to the near exclusion of the nymphs. Studies in which nymphs occurring in Thailand were described include Matsuki and Kitagawa (1986), Ferro and Sites (2006), Boonsoong and Chainthong (2014a, b), Chainthong and Boonsoong (2016), Makbun and Fleck (2018), Novelo-Gutiérrez and Sites (2019a, b, c), Chainthong et al. (2020), Fleck (2020), Saetung et al. (2020), and Keetapithchayakul et al. (2022), most concerning the Anisoptera family Gomphidae, except Novelo-Gutiérrez and Sites (2019b) which focused on the nymph of a cordulegastrid. Most of the knowledge on the nymphs inhabiting Thailand has been gleaned from descriptions of taxa from other parts of Asia.

Attributes of the aquatic insect community can be used to evaluate water quality, and this inexpensive technique has been applied worldwide, including in Thailand. To provide a broad understanding of the use of aquatic insects in biological monitoring, Mustow (2002) evaluated its use in rivers throughout Thailand, Parnrong (2002) reported on its application in the Mekong River watershed, and in northeastern Thailand, biotic indices (Uttaruk et al. 2011; Sirisinthuwanich et al. 2016) and a multimetrix index (Rattanachan et al. 2016) have been used to evaluate stream quality. Reports by Taeng-On Prommi and her colleagues have evaluated the entire aquatic insect community in particular river systems in northern Thailand (e.g., Payakka and Prommi 2014; Maneechan and Prommi 2015; Prommi and Payakka 2015), whereas others have focused on the response of certain taxa to water quality conditions (e.g., Mustow et al. 1997; Thani and Phalaraksh 2008; Jaihao and Phalaraksh 2013). Use of this technique requires the accurate identification of the insects to various taxonomic levels. Biological signal improves with finer taxonomic resolution, and Odonata and other groups have been evaluated only at the family level. This limitation is in part because of the lack of comprehensive taxonomic literature on odonate nymphs and that the nymphs of many species have not been described. Association of known adults with unknown nymphs can be achieved by matching DNA sequences or by rearing nymphs to adults in the laboratory. More faunistic work on aquatic insects in all groups and production of comprehensive resources for identification are needed to enable resource managers and others to use these communities to assess water quality as well as to enable scientists to address other important questions.

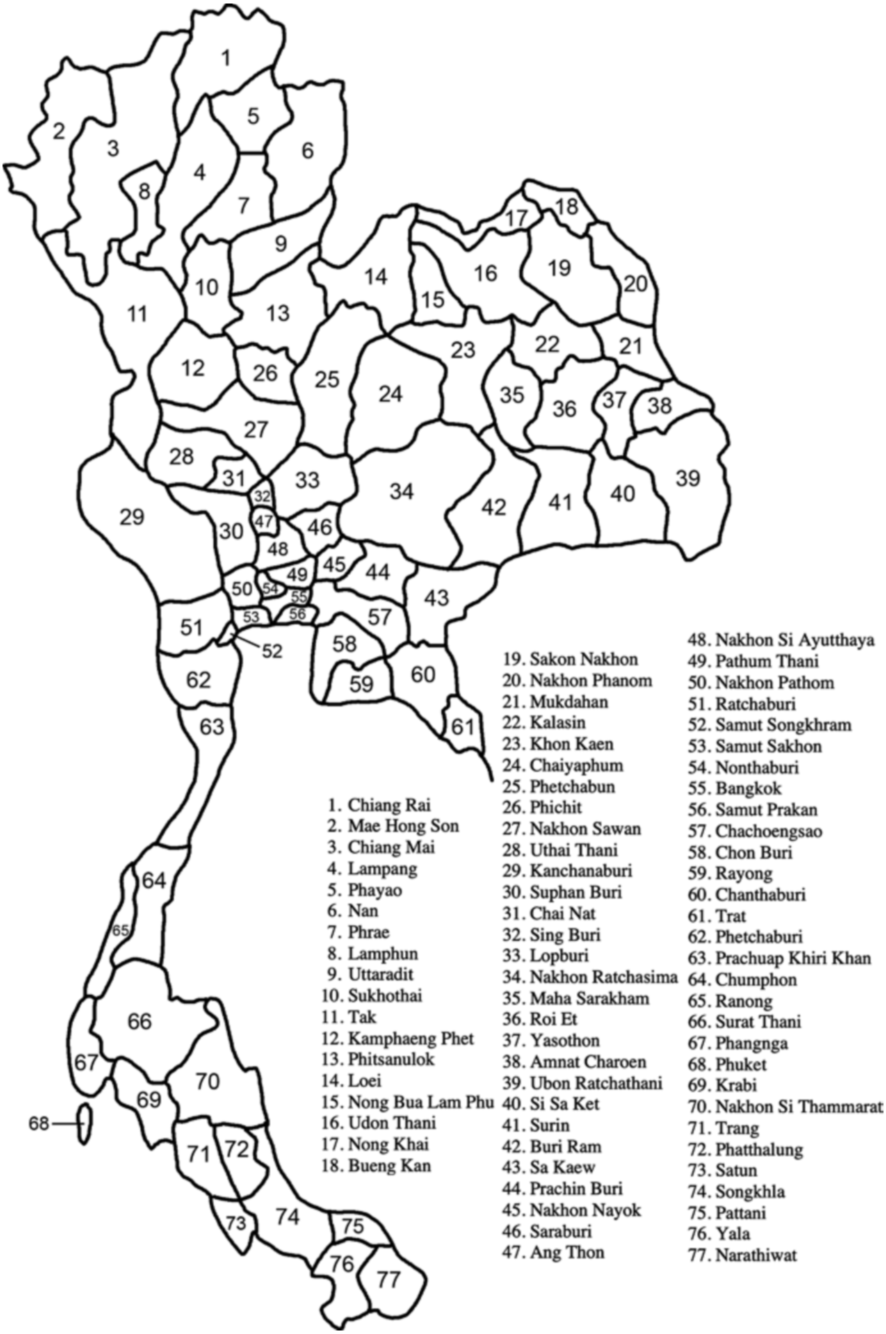

Fig. 1.1 The provinces of Thailand

Fig. 1.2 Relief map of Thailand. Note the northern mountains that extend to the south along the western border and the flat agricultural regions to the east

1.3 A List of the Anisoptera of Thailand (Modified From Hämäläinen and Pinratana 1999) (221 Species Recorded to Date). N = Nymph Described [Citation(s)]

AESHNIDAE

Anaciaeschna jaspidea (Burmeister, 1839)—**N** [Asahina 1957; Lieftinck 1962; Matsuki and Obana 1985; Ishida 1996]

Anaciaeschna martini (Selys, 1897)—**N** [Asahina 1957; Ishida 1996; Tze-wai et al. 2011]

Anax aurantiacus Makbun et al., 2022 [**N** included]

Anax ephippiger (Burmeister, 1839)—**N** [Gerken and Sternberg 1999; Sasamoto et al. 2022]

Anax guttatus (Burmeister, 1839)—**N** [Asahina 1957; Sangal and Kumar 1970; Matsuki 1987; Ishida 1996]

Anax indicus Lieftinck, 1942

Anax nigrofasciatus Oguma, 1915—**N** [Asahina 1974; Ishida 1996; Sasamoto and Ushijima 2000]

Anax panybeus Hagen, 1867—**N** [Asahina 1957, 1974; Matsuki 1987; Ishida 1996]

Cephalaeschna asahinai Karube, 2011

Gynacantha basiguttata Selys, 1882

Gynacantha bayadera Selys, 1891

Gynacantha corbeti Lempert, 1999

Gynacantha demeter Ris, 1911

Gynacantha incisura Fraser, 1935

Gynacantha limbalis Karsch, 1892

Gynacantha phaeomeria Lieftinck, 1960

Gynacantha saltatrix Martin, 1909—**N** [Tze-wai et al. 2011]

Gynacantha subinterrupta Rambur, 1842—**N** [Tze-wai et al. 2011]

Heliaeschna crassa Krüger, 1899

Heliaeschna simplicia (Karsch, 1891)—**N** [Butler and Orr 2013]

Heliaeschna uninervulata Martin, 1909—**N** [Orr and Ngiam 2011]

Indaeschna grubaueri (Förster, 1904)—**N** [Orr 1994, 2005]

Oligoaeschna sirindhornae Ngiam and Orr, 2017

Periaeschna nocturnalis Fraser, 1927

Petaliaeschna flavipes Karube, 1999—**N** [Kawashima and Karube 2006]

Planaeschna chiengmaiensis Asahina, 1981

Planaeschna intersedens (Martin, 1909)

Planaeschna sp.

Polycanthagyna erythromelas (McLachlan, 1896)—**N** [Matsuki and Lien 1985]

Polycanthagyna ornithocephala (McLachlan, 1896)—**N** [Wong et al. 2012]

Sarasaeschna minuta (Asahina, 1986)

Sarasaeschna pramoti (Yeh, 2000)

Tetracanthagyna brunnea McLachlan, 1898

Tetracanthagyna plagiata (Waterhouse, 1877)—**N** [Orr et al. 2010]

Tetracanthagyna waterhousei McLachlan, 1898—**N** [Matsuki 1988a; Wan et al. 2011]

GOMPHIDAE

Acrogomphus malayanus? Laidlaw, 1925—**N** [Lieftinck 1941; Orr 2005]

Amphigomphus somnuki Hämäläinen, 1996—**N** [Novelo-Gutiérrez and Sites 2019a]

Anisogomphus yanagisawai Sasamoto, 2015

Anisogomphus yingsaki Makbun, 2017

Asahinagomphus insolitus (Asahina, 1986)

Asiagomphus xanthenatus (Williamson, 1907)

Burmagomphus arboreus Lieftinck, 1940

Burmagomphus arthuri Lieftinck, 1953
Burmagomphus asahinai Kosterin, Makbun and Dawwrueng, 2012
Burmagomphus chiangmaiensis Makbun, 2017
Burmagomphus divaricatus Lieftinck, 1964—**N** [Lieftinck 1964; Yang and Davies 1996]
Burmagomphus johnseni Lieftinck, 1966
Burmagomphus williamsoni Förster, 1914—**N** [Lieftinck 1964; Orr 2005]
Davidius fruhstorferi Martin, 1904—**N** [Chao 1990]
Davidius sp.
Euthygomphus yunnanensis (Zhou and Wu, 1992)
Gomphidia abbotti Williamson, 1907
Gomphidia kruegeri Martin, 1904—**N** [Chao 1990]
Gomphidia maclachlani Selys, 1873
Gomphidictinus perakensis (Laidlaw, 1902)—**N** [Matsuki 1990; Ferro and Sites 2006]
Heliogomphus selysi Fraser, 1925—**N** [Boonsoong and Chainthong 2014a]
Heliogomphus sp.
Ictinogomphus decoratus (Selys, 1854)—**N** [Orr 2005]
Ictinogomphus rapax (Rambur, 1842)—**N** [Begum et al. 1980; Kumar 1985; Chao 1990; Butler 2007]
Lamelligomphus castor (Lieftinck, 1941)—**N** [Lieftinck 1941]
Lamelligomphus risi (Fraser, 1922)
Lamelligomphus sp. (aff. *castor* Lieftinck, 1941)
Leptogomphus gestroi Selys, 1891
Leptogomphus inclitus Selys, 1878
Leptogomphus risi Laidlaw, 1932
Leptogomphus sp.
Macrogomphus albardae Selys, 1878
Macrogomphus kerri Fraser, 1932
Macrogomphus matsukii Asahina, 1986
Macrogomphus parallelogramma (Burmeister, 1839)
Macrogomphus thoracicus McLachlan, 1884
Mattigomphus pinratani (Hämäläinen, 1991)
Megalogomphus sumatranus (Krüger, 1899)—**N** [Lieftinck 1941 as *M.icterops*]
Megalogomphus sp.
Merogomphus pavici Martin, 1904
Microgomphus chelifer Selys, 1859—**N** [Ngiam 2010 as *Heliogomphus* cf. *retroflexus*]
Microgomphus jurzitzai Karube, 2000
Microgomphus farrelli Makbun and Fleck, 2018 [**N** included]
Microgomphus svihleri (Asahina, 1969)—**N** [Boonsoong and Chainthong 2014b as *M. thailandicus*]
Nepogomphus walli (Fraser, 1924)—**N** [Yang and Davies 1993; Sasamoto and Kawashima 2009a]
Nihonogomphus pulcherrimus (Fraser, 1927)