CHAPTER 4
RESULTS

4.1 Diversity of Odonata in Doi Suthep-Pui National Park

After observing in eleven sites, the altitude of which ranges from 400 to 1,400 meters, in the Doi Suthep-Pui National Park for twelve months, 83 species in 13 families from two suborders were recorded (Table 2). Libellulidae was the most abundant family (24 species). It was followed by Coenagrionidae (11 species) and Platycnemididae (9 species), respectively. Megapodagrionidae and Philogangidae were the least speciose families with only one species in each. Among these 83 species, eight species are new records for the park. Five species were from two Anisopteran families, Aeshnidae and Libellulidae: *Polycanthagyna erythromelas*, *Cratilla lineata calverti*, *Hylaeothemis clementia*, *Potamarcha congener*, and *Tramea transmarina euryale*. Another three species were from the zygopteran family Coenagrionidae, viz. *Ischnura aurora aurora*, *Ceriagrion indochinense,* and *Mortonagrion aborense* (Table 2). This increased the total number of odonate species known from the Doi Suthep-Pui National park to 134.

Table 2 Number of species and new records found in this study.

Family	Number of species	Number of new record
Anisoptera	**40**	**5**
Aeshnidae	8	1
Corduliidae	4	-
Gomphidae	4	-
Libellulidae	24	4
Zygoptera	**43**	**3**
Calopterygidae	7	-
Chlorocyphidae	3	-
Coenagrionidae	11	3
Euphaeidae	3	-
Megapodagrionidae	1	-
Philogangidae	1	-
Platycnemididae	9	-
Platystictidae	4	-
Protoneuridae	4	-
Total	**83**	**8**

The number of species observed in each study site was different. Mon Tha Than waterfall was the most speciose place with 44 species recorded (Table 3). It was followed by Huay Kaew waterfall and Sri Sangwan waterfall where 34 and 31 species were observed, respectively. The site with the least number of species was Mok Fa waterfall where only 12 species were recorded. When number of species with altitude of each study site is compared, it was likely that the higher altitude, the lower number of species (Fig. 8).

The most number of individuals was found in Mon Tha Than waterfall with 965 individuals recorded (Table 4) followed by Hauy Kaew waterfall and Mae Sa waterfall, respectively. Conversely, Pond near the Bhubing Palace had the lowest number of individuals which was only 174 individuals observed. Libellulidae was the most abundant family in this study with 1,531 individuals recorded (Table 5). It was followed by Platycnemididae and Chlorocyphidae. In contrast, Philogangidae was observed only two individuals.

Table 3 Altitude and number of odonate species recorded in each study site.

No.	Study site	Altitude (m)	Number of species
1	Mae Sa waterfall	400	22
2	Huay Kaew waterfall	402	34
3	Hauy Rai reservoir	424	25
4	Tad Mok waterfall	540	28
5	Sri Sangwan waterfall	639	31
6	Mon Tha Than waterfall	715	44
7	Pha Lad stream	753	17
8	Mok Fa waterfall	889	12
9	Sai Yoi waterfall	992	24
10	Pau Pau waterfall	1,194	27
11	Pond near the Bhubing Palace	1,383	15

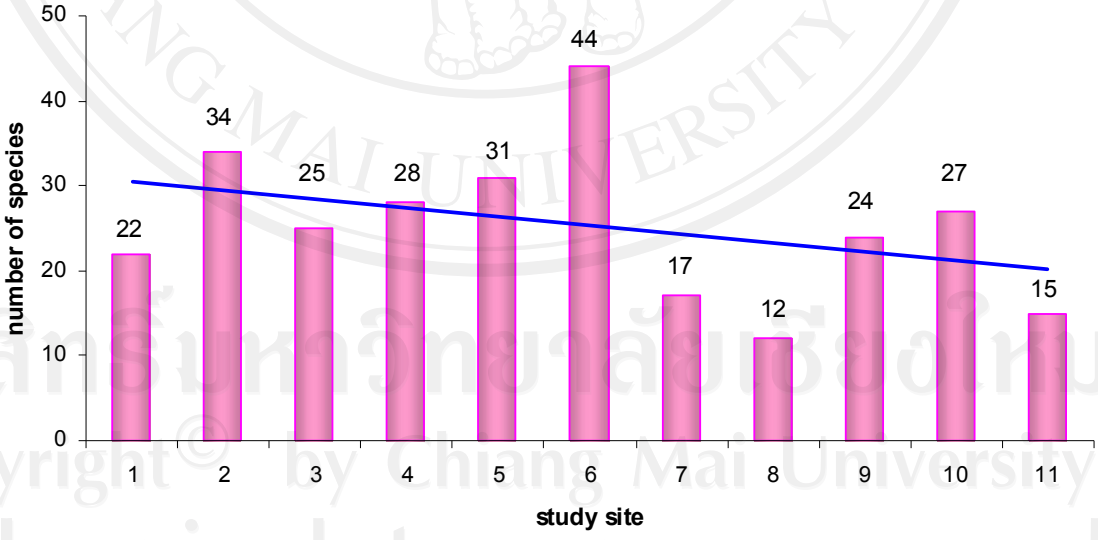


Fig. 8 Relationship between number of species and altitude of each study site: 1. Mae Sa waterfall (400 m), 2. Huay Kaew waterfall (402 m), 3. Huay Rai reservoir (424 m), 4. Tad Mok waterfall (540 m), 5. Sri Sangwan waterfall (639 m), 6. Mon Tha Than waterfall (715 m), 7. Pha Lad stream (753 m), 8. Mok Fa waterfall (889 m), 9. Sai Yoi waterfall (992 m), 10. Pau Pau waterfall (1,194 m), 11. Pond near the Bhubing Palace (1,383 m)

Calculated biological indices indicated that the evenness (E), diversity (H') and richness (R) varied among the eleven sites (Table 4). Mae Sa waterfall had the highest value of evenness index which was 0.929 followed by Huay Rai reservoir (0.927) and Tad Mok waterfall (0.919). The lowest evenness was recorded in Pha Lad stream (0.857). The highest diversity and richness was in Mon Tha Than waterfall which is 3.364 and 6.257, respectively. In contrast, Mok Fa waterfall was the poorest among these eleven sites (2.195 and 1.957). It was followed by Pond near the Bhubing Palace (2.335 and 2.714) and Pha Lad stream (2.429 and 2.856), respectively.

Table 4 Total individuals recorded, evenness (E), diversity (H'), and richness (R) in each study site.

No.	Study site	Total individuals recorded	E	H'	R
1	Mae Sa waterfall	631	0.929	2.872	3.257
2	Huay Kaew waterfall	828	0.893	3.149	4.911
3	Hauy Rai reservoir	265	0.927	2.984	4.301
4	Tad Mok waterfall	416	0.919	3.064	4.477
5	Sri Sangwan waterfall	419	0.873	2.998	4.969
6	Mon Tha Than waterfall	965	0.889	3.364	6.257
7	Pha Lad stream	271	0.857	2.429	2.856
8	Mok Fa waterfall	276	0.883	2.195	1.957
9	Sai Yoi waterfall	343	0.904	2.872	3.940
10	Pau Pau waterfall	558	0.913	3.009	4.111
11	Pond near the Bhubing Palace	174	0.862	2.335	2.714

Table 5 Total number of individuals in each family recorded in this study.

No.	family	Total number of individuals
Zygoptera		**3,526**
1	Calopterygidae	435
2	Chlorocyphidae	615
3	Coenagrionidae	265
4	Euphaeidae	423
5	Megapodagrionidae	76
6	Philogangidae	2
7	Platycnemididae	1,253
8	Platystictidae	151
9	Protoneuridae	306
Anisoptera		**1,620**
10	Aeshnidae	9
11	Corduliidae	43
12	Gomphidae	37
14	Libellulidae	1,531
Total		**5,146**

4.2 Checklist and phenology of Odonata recorded in this study

Totally, 83 odonate species were found in this study. Name of families, genera and species were arranged in alphabetic order. The family name was bolded and the species name was italicized. The species presented in each month was marked as 'x'. New record for the park was asterisked.

species	Months in which recorded											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
ZYGOPTERA												
Calopterygidae												
Caliphaea thailandica					x			x				
Matrona nigripectus	x				x				x	x	x	x
Mnais andersoni		x	x		x							
Neurobasis chinensis	x	x			x		x	x	x	x		x
Noguchiphaea yoshikoae											x	
Vestalis gracilis					x	x	x	x	x	x	x	x
Vestalis smaragdina									x	x	x	x
Chlorocyphidae												
Rhinocypha fenestrella	x	x		x	x	x	x	x	x	x	x	x
Rhinocypha biforata	x	x		x	x	x	x	x	x	x		x
Rhinocypha perforata							x	x	x	x		x
Coenagrionidae												
Aciagrion pallidum	x		x						x	x	x	x
Agriocnemis femina femina		x										x
Argiocnemis rebescens rubeola		x	x			x		x		x		
Ceriagrion chaoi								x				
Ceriagrion fallax pendleburyi			x					x				
**Ceriagrion indochinense*					x							
**Ischnura aurora aurora*					x							
**Mortonagrion aborense*	x	x			x							
Pseudagrion microcephalum	x											
Pseudagrion pruinosum	x	x		x	x		x	x	x	x		x
Pseudagrion rubriceps rubriceps	x	x		x	x		x			x		
Euphaeidae												
Anisopleura furcata					x		x					
Euphaea masoni	x	x			x		x	x	x	x	x	x
Euphaea ochracea					x	x	x	x	x	x	x	x
Megapodagrionidae												
Burmagiolestes melanothorax					x	x	x	x		x	x	
Philogangidiae												
Philoganga loringae				x								

species	Months in which recorded											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Platycnemididae												
Calicnemia imitans		x		x	x	x			x			
Calicnemia miles			x		x	x						
Coeliccia chromothorax			x				x	x	x	x	x	x
Coeliccia didyma didyma				x			x	x	x	x		x
Coeliccia doisuthepensis					x	x		x				
Coeliccia loogali					x	x	x	x	x	x	x	
Coeliccia poungyi	x				x			x	x	x	x	x
Copera marginipes	x	x	x	x	x	x	x	x	x	x	x	x
Copera vittata	x	x			x	x	x		x	x		x
Platystictidae												
Drepanosticta anascephala					x		x	x				
Protosticta curiosa					x	x	x	x				
Protosticta grandis				x		x						
Protosticta khaosoidaoensis					x		x	x				
Protoneuridae												
Prodasineura auricolor						x						
Prodasineura autumnalis	x	x			x		x	x	x	x		x
Prodasineura doisuthepensis					x	x						
Prodasineura sp. [nec. *verticalis*]		x		x	x	x						
ANISOPTERA												
Aeshnidae												
Anax immaculifrons				x					x			
Anax guttatus			x									
Gynacantha subinterrupta								x				
**Polycanthagyna erythromelas*												x
Corduliidae												
Idionyx selysi					x	x						
Idionyx sp. [nec. *optata*]					x							
Macromia moorei malayana			x					x	x	x		
Macromidia genialis shanensis						x	x					
Gomphidae												
Anisogomphus sp.							x	x	x			
Asiagomphus xanthenatus xanthenatus								x	x			
Burmagomphus divaricatus							x	x				
Gomphidictinus perakensis						x	x	x				
Heliogomphus selysi						x	x					
Ictinogomphus decoratus melaenops							x					
Leptogomphus gestroi					x	x						

species	Months in which recorded											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Paragomphus capricornis				x	x	x						
Libellulidae												
Brachythemis contaminata					x							
**Cratilla lineata calverti*								x	x			
Crocothemis servilia servilia	x	x					x				x	x
Diplacodes trivialis			x	x			x	x	x		x	x
**Hylaeothemis clementia*							x					
Indothemis carnatica			x					x				
Neurothemis fulvia	x	x	x				x	x	x	x		x
Neurothemis intermedia atalanta	x											x
Orthetrum chrysis	x	x			x	x			x			x
Orthetrum glaucum	x	x	x	x	x	x	x	x	x	x	x	x
Orthetrum pruinosum neglectum		x	x		x	x		x	x	x		x
Orthetrum sabina sabina	x							x	x			x
Orthetrum triangulare triangulare			x	x	x	x	x	x	x	x		x
Pantala flavescens	x	x	x					x	x	x		x
**Potamarcha congener*	x							x				x
Pseudothemis jorina							x	x				
Rhyothemis phyllis phyllis					x							
Rhyothemis plutonia					x							
Rhyothemis variegata variegata					x							
Tholymis tillarga		x	x									x
**Tramea transmarina euryale*			x									x
Trithemis aurora	x	x		x	x			x	x	x		x
Trithemis festiva	x	x			x	x		x	x	x		x

4.3 Key to suborder of Odonata in this study

- Eyes well separated by a space greater than their own diameter. Fore- and hindwings are essentially similar in shape and venation, narrow at base …….. **Zygoptera** (p. 26)
- Eyes usually touching broadly along the mid line, or if separated, never by a space greater than their own diameter. Hindwings expanded at base. Venation of forewing and hindwing are very different.…….…. **Anisoptera** (p. 45)

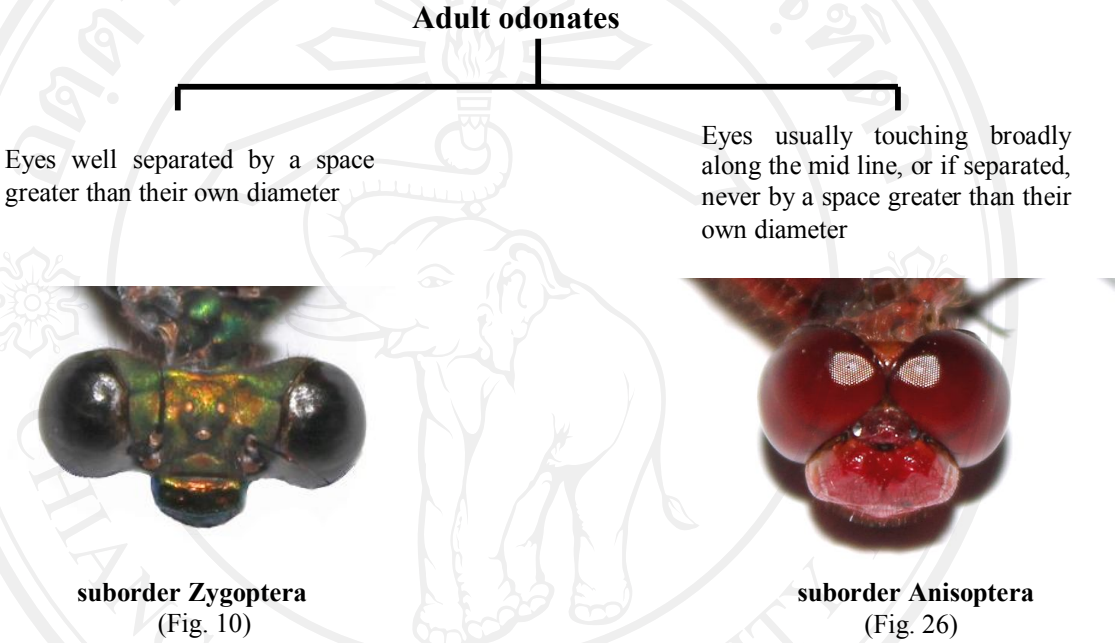


Fig. 9 Key to suborder of Odonata recorded in this study.

4.4 Key to zygopteran families recorded in this study

1. Numerous (5-70+) antenodal crossveins in the costal space of both wings. Wings often with opaque markings, sometimes iridescent …… **2**
1'. Only two antenodal crossveins in costal space..…….. **5**

2. Five to eight antenodal crossveins. Wings strongly stalked just basal to level of arculus. Medium size species; wings hyaline .....…….. **Philogangidae**
2'. Few (5-15) or numerous antenodal crossveins. Wings are not stalked. Males often brightly colored with opaque markings on the wings..…….…… **3**

3. Antenodal crossveins in costal and subcostal space not aligned distal to level of arculus. Only 5-15 antenodals in costal space. Front of head produced to form a large projecting rostrum or 'nose'. Mostly small stout species. Abdomen shorter than hindwing and often brightly colored…**Chlorocyphidae**

3’. Most of the numerous antenodal crossveins in costal and subcostal space aligned except distally near the subnodus. Front of head not produced into a rostrum. Abdomen longer than wings……. **4**

4. Only one crossveins in cubital space basal to arculus. Forewing markedly longer than hindwing. Males often with small speudoauricles on abdominal segment 2. Head, synthorax and abdomen never bright metallic-green. Robust species with short legs……..……. **Euphaeidae**

4’. Several crossveins in cubital space basal to arculus. Wings of nearly equal legth, broad and paddle-shaped. Abdominal segments without pseudoauricles. Head, synthorax and abdomen mostly bright metallic green. Slimly built long-legged species……. **Calopterygidae**

5. Numerous supplementary veins inserted between the main veins from the distal wing margin to the level of pterostigma. Fairly robust species resting with wings open ……**Megapodagrionidae**

5’. Supplementary veins absent from the wing tip, or if present, to the depth of 1-2 cells only……... **6**

6. Anal vein absent or very poorly developed, never extending beyond distal end of quadrilateral. CuP meeting wing margin less than halfway along its lengt...**7**

6’. Anal vein well developed, extending at least two cells beyond distal end of quadrilateral. CuP meeting wing margin at least halfway along its length… **8**

7. Wings narrow, terminally falcate. Small sub-basal crossveins between CuP and wing margin. Sectors of arculus fused basally to form a short stalk. Small very slim species, often metallic, male appendages elongate and branched…… **Platystictidae**

7’. Wings not falcate. No sub-basal crossveins between CuP and wing margin. Sectors of arculus separated basally. Small fine non-metallic species; male appendages aquat……..…... **Protoneuridae**

8. Costal side of quadrilateral in forewing two fifths or less length of anal side. Tiny to large species ……**Coenagrionidae** (most)

8’. Costal side of quadrilateral in forewing at least half length of anal side..…… **9**

9. Hind tibia with 4-8 short stout spines; legs short, hind tibia less than length of humeral suture. Male inferior appendages rarely as long as segment 10, generally squat and often shorter than superior……..…….. **Coenagrionidae**

9’. Hind tibia with 10-16 long filamentous spines; mostly longer than humeral suture. Male inferior appendages thin, tapered, longer than both superiors and segment 10……..…… **Platycnemididae**

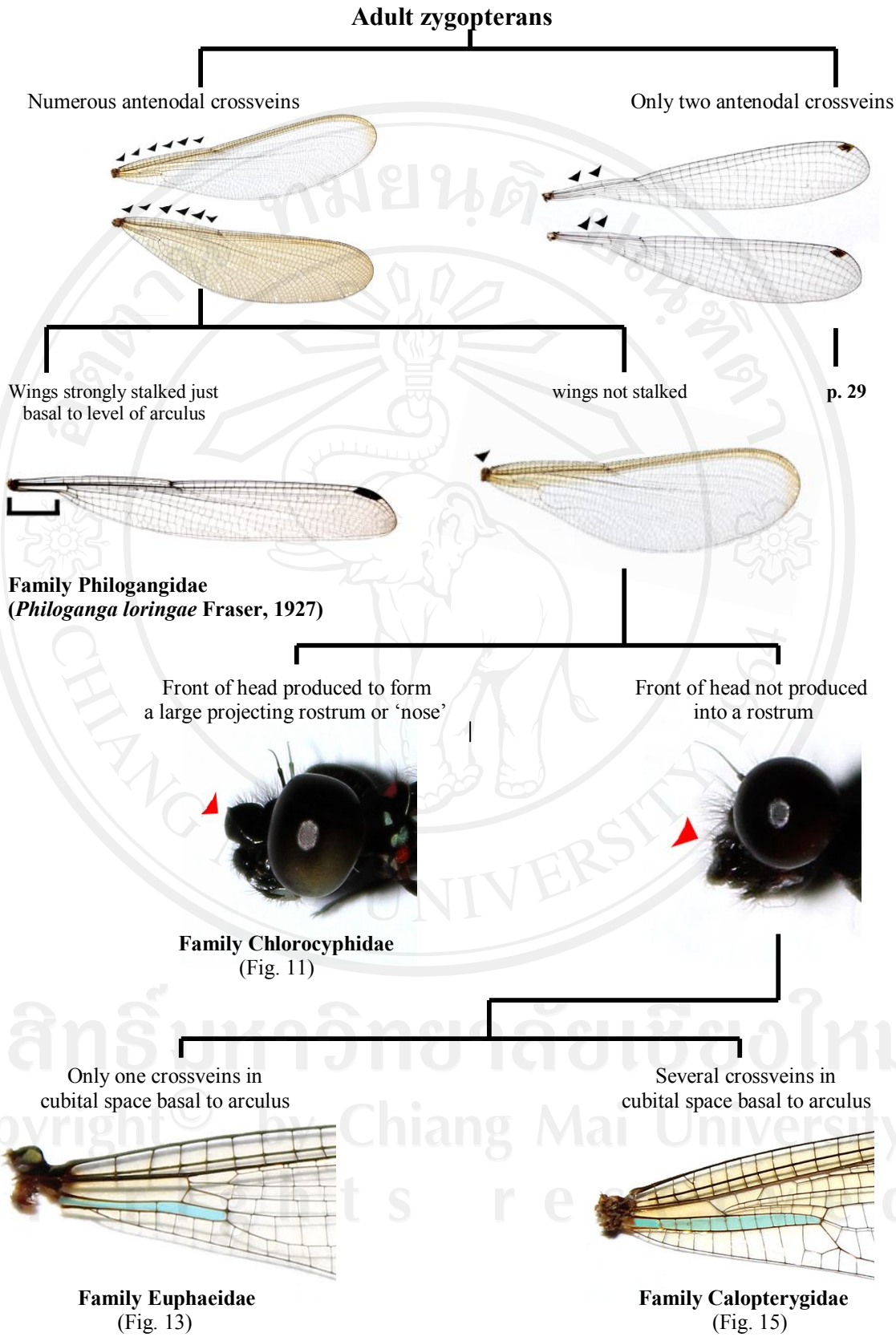


Fig. 10 Key to zygopteran families recorded in this study.

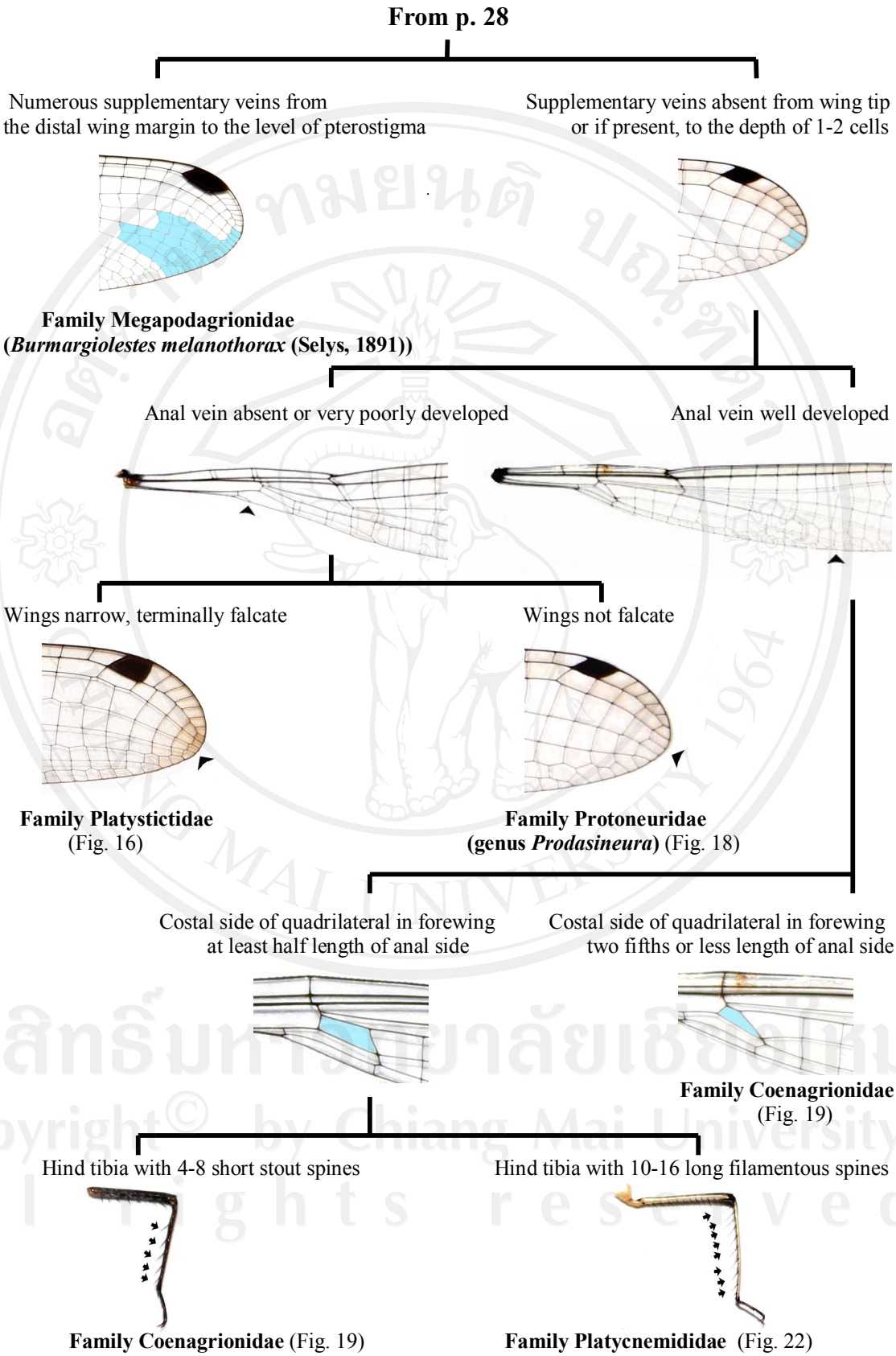


Fig. 10 Key to zygopteran families recorded in this study (continued).

4.5 Key to genera and species of Zygoptera recorded in this study

4.5.1 Key to genera of family Chlorocyphidae recorded in this study

1. Mesothoracic triangle 1/4 - 1/3 the length of middorsal carina; venation rather close……..……..……..…… *Heliocypha*
1'. Mesothoracic triangle expanding to 1/2 or the whole length of middorsal carina; venation close……..……..……. *Aristocypha*

4.5.2 Key to species of genus *Heliocypha* recorded in this study

1. Apical half of male hindwings opaque with two rows of vitreous spots ……..…… *Heliocypha perforata limbata* (Selys, 1879)
1'. Apical third of male hindwings opaque with single row of vitreous spots ……. *Heliocypha biforata* (Selys, 1859)

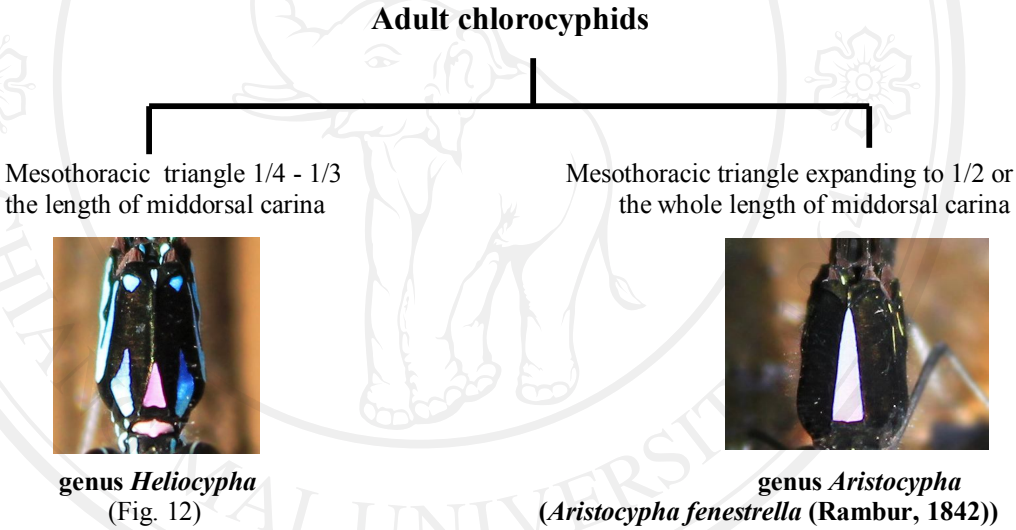


Fig. 11 Key to genus of family Chlorocyphidae recorded in this study.

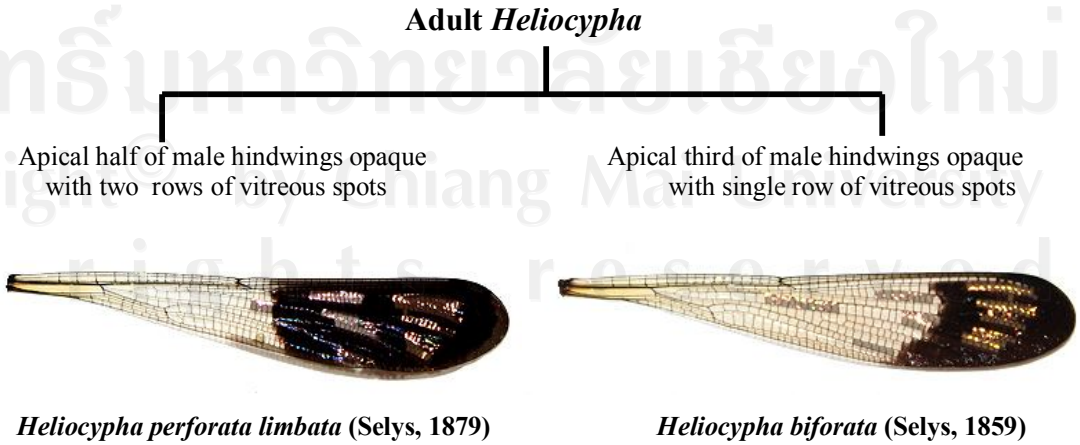


Fig. 12 Key to species of genus *Heliocypha* recorded in this study.

4.5.3 Key to genera of family Euphaeidae in this study

1. Costal margin of hindwing of the male running straight from base to nodus
…… *Euphaea*

1'. Costal margin of hindwing of the male with obtuse projecting angle between base and nodus…….. *Anisopleura*

4.5.4 Key to species of genus *Euphaea* recorded in this study

1. Male forewing banded with black, leaving basal 1/4 and apical 1/5 hyaline; hindwing entirely black or just leaving apical 1/5 ……..
…….. *Euphaea masoni* Selys, 1879

1'. Male forewing entirely tinged with saffron, deeper in the basal half, hindwing saffron colored …..……...… *Euphaea ochracea* Selys, 1859

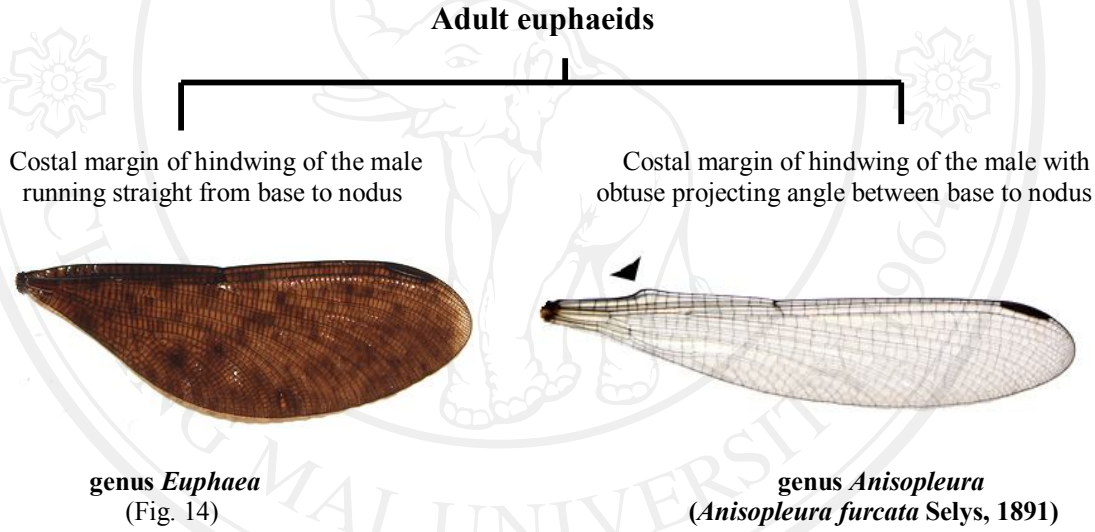


Fig. 13 Key to genus of family Euphaeidae recorded in this study.

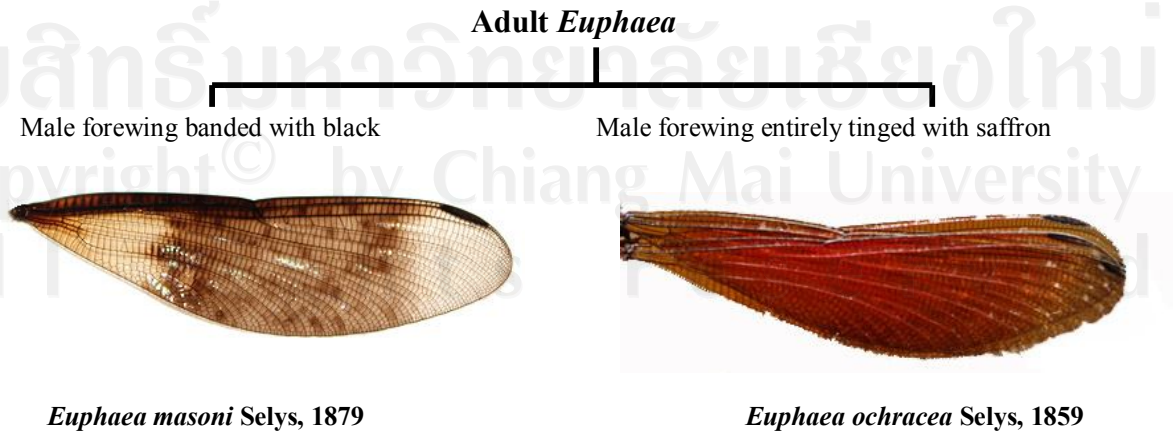


Fig. 14 Key to species of genus *Euphaea* recorded in this study.

4.5.5 Key to genera of family Calopterygidae recorded in this study

1. Arculus angulated; sectors of arculus separated at origin, main sectors not forked **5**
1'. Arculus oblique; sectors of arculus arising from a single point, most main sectors forked **2**

2. Pterostigma present ..... *Caliphaea*
2'. Pterostigma absent **3**

3. Quadrilateral entire..... *Noguchiphaea*
3'. Quadrilateral crossed with 1-6 crossveins..... **4**

4. Crossveins in cubital space arranged regularly..... *Vestalis*
4'. Crossveins in cubital space arranged irregularly..... *Vestalaria*

5. Basal space crossed **6**
5'. Basal space entire; pterostigma present..... *Mnais*

6. All wings of both sexes opaque black..... *Matrona*
6'. Forewings of both sexes hyaline, hindwings opaque in males or hyaline in females ..... *Neurobasis*

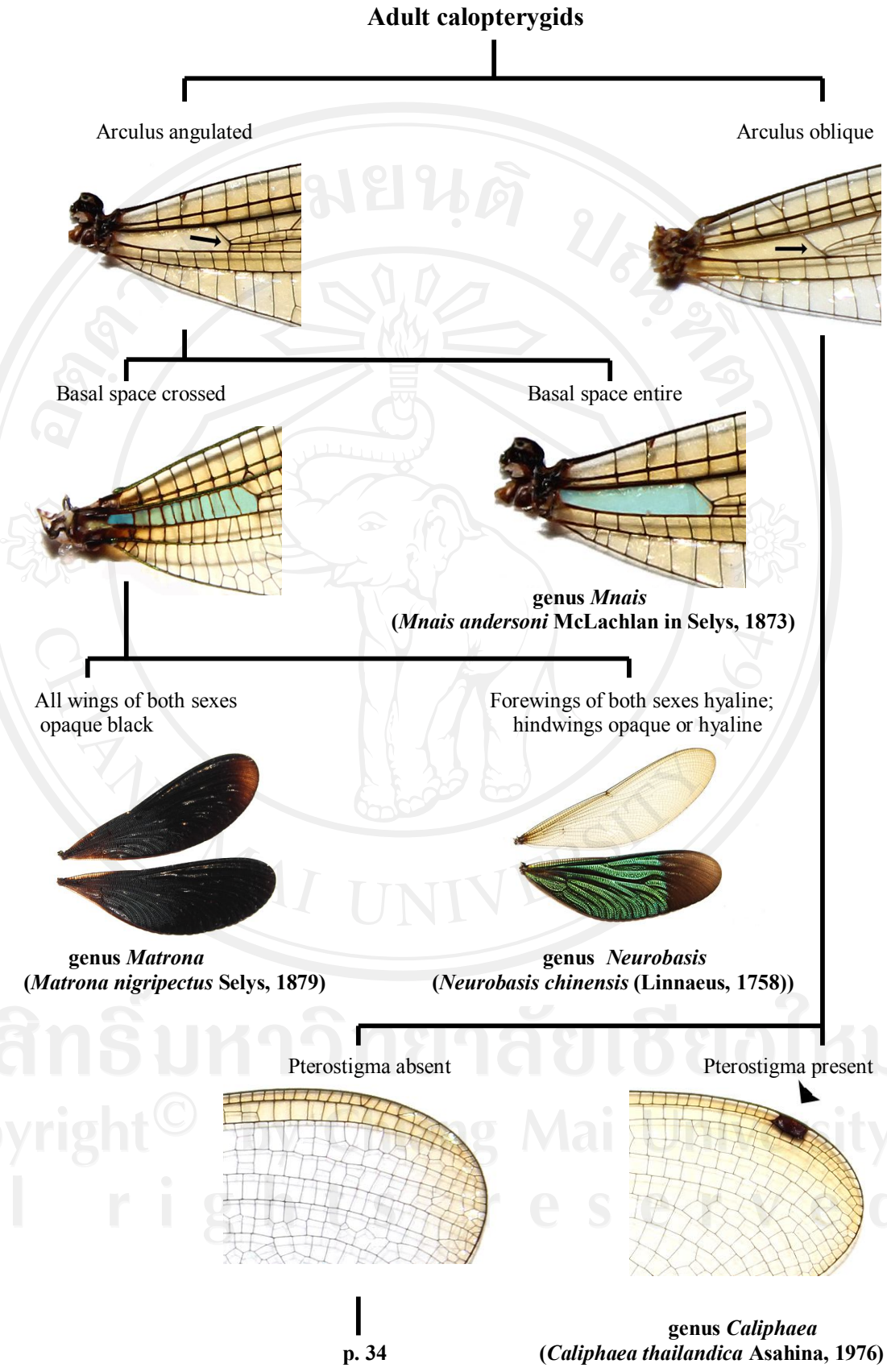
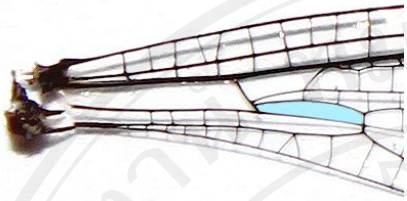


Fig. 15 Key to genera and species of family Calopterygidae recorded in this study.

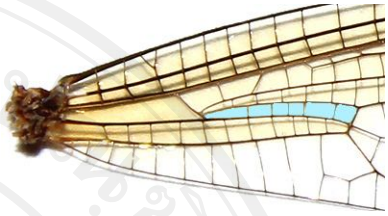
From p. 33

Quadrilateral entire

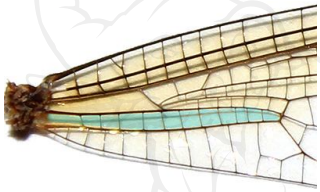


genus *Noguchiphaea*
(*Noguchiphaea yoshikoae* Asahina, 1976)

Quadrilateral crossed with 1-6 crossveins

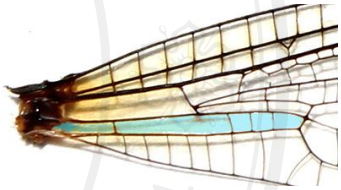


Crossveins in cubital space arranged regularly



genus *Vestalis*
(*Vestalis gracilis* (Rambur, 1842))

Crossveins in cubital space arranged irregularly



genus *Vestalaria*
(*Vestalaria smaragdina* (Selys, 1879))

Fig. 15 Key to genera and species of family Calopterygidae recorded in this study (continued).

4.5.6 Key to genera of family Platystictidae recorded in this study

1. Anal bridge crossvein present, sometimes making a V-shaped image with anal crossings (ac) ……. *Drepanosticta*
1'. Anal bridge crossvein absent …….. *Protosticta*

4.5.7 Key to species of genus *Protosticta* recorded in this study

1. Abdomen extremely long, more than twice the length of hindwing ….. ……..*Protosticta curiosa* Fraser, 1934
1'. Abdomen long, not exceeding twice the length of hindwing …….… **2**

2. Prothorax entirely white or very pale smoky brown, with one black spot in posterior lobe; abdominal segment 9 tinted with blue on dorsum; caudal appendages entirely dark brownish, superior appendages thorny on distal half …… *Protosticta khaosoidaoensis* Asahina, 1984
2'. Prothorax pale yellowish brown on dorsum with dark markings; abdomen pale brown; caudal appendages short and wholly yellowish, superior appendages curved and swelling without spiny on distal half; large-sized robust species…… *Protosticta grandis* Asahina, 1985

Adult platystictids

Anal bridge crossvein present, sometimes making a V-shaped image with anal crossings (ac)

genus *Drepanosticta*
(*Drepanosticta anascephala* Fraser, 1933)

Anal bridge crossvein absent

genus *Protosticta*
(Fig. 17)

Fig. 16 Key to genera of family Platystictidae recorded in this study.

Adult *Protosticta*

Abdomen extremely long, more than twice the length of hindwing

***Protosticta curiosa* Fraser, 1934**

Abdomen long, never exceeding twice the length of hindwing

Caudal appendages entirely dark brownish, superior appendages curved and thorny on distal half

***Protosticta khaosoidaoensis* Asahina, 1984**

Caudal appendages short and wholly yellowish, superior appendages curved , not spiny on distal half

***Protosticta grandis* Asahina, 1985**

Fig. 17 Key to species of genus *Protosticta* recorded in this study.

4.5.8 Key to species of genus *Prodasineura* recorded in this study

1. Thorax without any markings in mature male.....
…… *Prodasineura autumnalis* (Fraser, 1922)
1'. Thorax marked with colored stripes…….…….. **2**

2. Caudal appendages black.*Prodasineura* sp. [nec. *verticalis* Selys, 1860]
2'. Caudal appendages blue…..…….…..... **3**

3. Dorsum of synthorax wholly blue.....
…… *Prodasineura doisuthepensis* Hoess, 2007
3'. Dorsum of synthorax wholly yellow…….
…….. *Prodasineura auricolor* (Fraser, 1927)

Fig. 18 Key to species of genus *Prodasineura* recorded in this study.

4.5.9 Key to genera of family Coenagrionidae recorded in this study

1. Arculus situated at the level of distal antenodal crossvein …… **2**
1'. Arculus situated distal to the level of distal antenodal crossvein …..... **5**

2. Anal bridge arising from the hind border of wing at point where anal crossing meet it ……**3**
2'. Anal bridge arising from the hind border of wings more or less proximal to point where anal crossing meet it …… *Ischnura*

3. No postocular colored spots on head; a prominent ridge on frons; head and synthorax uniformed color without any dark marking ……
…… *Ceriagrion*
3'. Postocular colored spots present on head; no ridge on frons; head and synthorax not uniformed color, and usually with black or dark marking.
…….. **4**

4. Pterostigma in forewing larger than that in hindwing; abdomen usually very long and slender; female with an apical ventral spine on abdominal segment 8 …….. *Aciagrion*
4'. Pterostigma in both wings of the same size; abdomen long and slender; female without apical ventral spine on abdominal segment 8 ……
……..……... *Pseudagrion*

5. 10-12 postnodal crossveins in forewings ……..……. *Argiocnemis*
5'. 6-8 postnodal crossveins in forewings ……..…….. **6**

6. The junction of anal bridge and 1A markedly angulated …….……
…… *Agriocnemis*
6'. The junction of anal bridge and 1A not angulated, continued on in the same straight line…….……. *Mortonagrion*

4.5.10 Key to species of genus *Ceriagrion* recorded in this study

1. Synthorax orange with abdomen yellow or greenish yellow ……. **2**
1'. Synthorax and abdomen reddish orange or yellowish orange……...
……..……. *Ceriagrion chaoi* Schmidt, 1964

2. Abdominal segment 7-10 black dorsally.....
……*Ceriagrion fallax pendleburyi* Laidlaw, 1931
2'. Abdominal segment 9-10 tinted with orange ..……...
……..……. *Ceriagrion indochinense* Asahina, 1967

4.5.11 Key to species of genus *Pseudagrion* recorded in this study

1. Face, frons, and vertex bright reddish orange or dark ochreous …….... **2**
1'. Face frons, and vertex blue ….……
……...…….. *Pseudagrion microcephalum* (Rambur, 1842)

2. Thorax golden green on dorsum, azure blue on side, sparingly marked with black; never pruinosed ……. ……..…… *Pseudagrion rubriceps rubriceps* Selys, 1876

2'. Thorax black, densely pruinosed, especially on dorsum…….. …… *Pseudagrion pruinosum* (Burmeister, 1839)

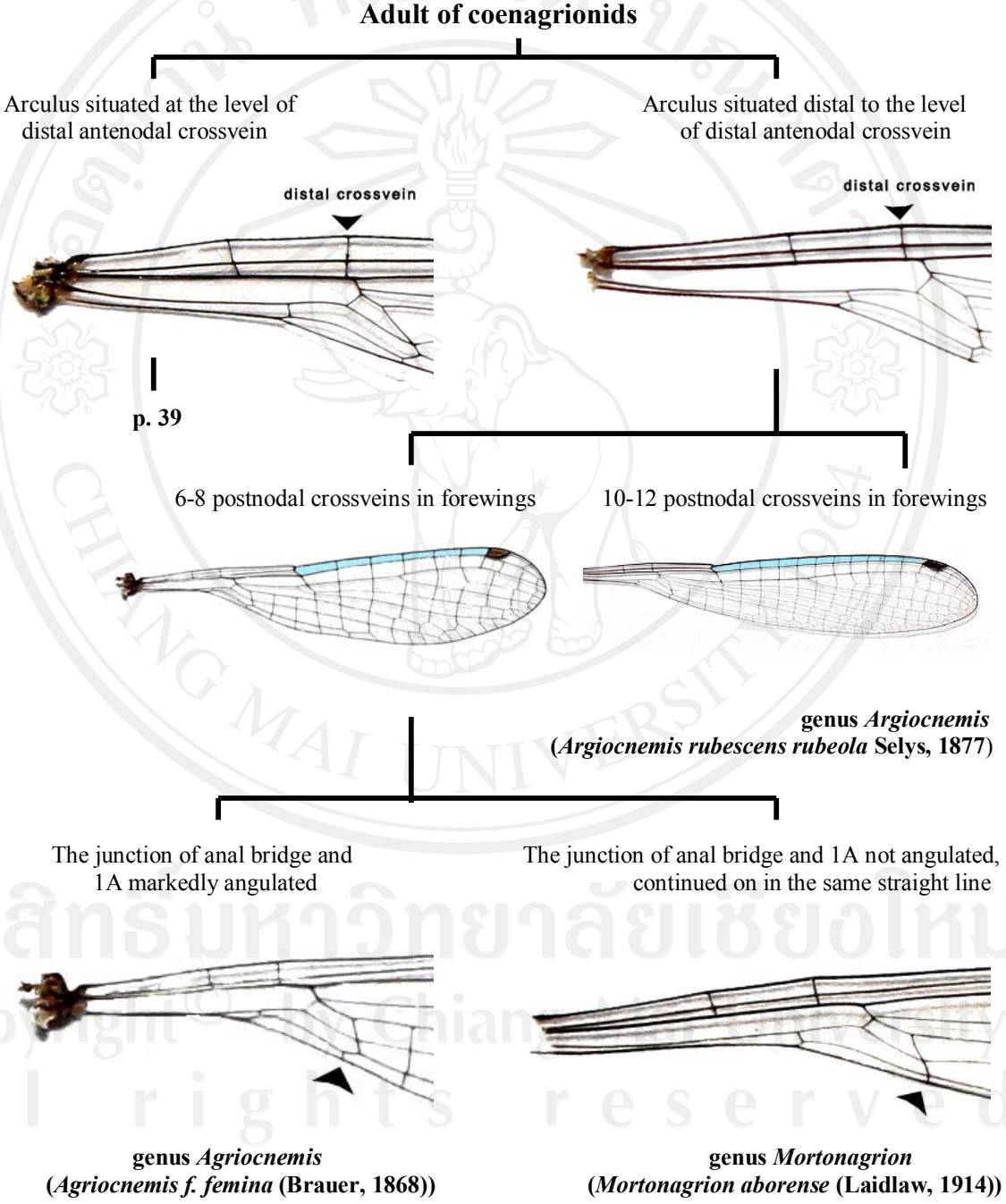


Fig. 19 Key to genera of family Coenagrion recorded in this study.

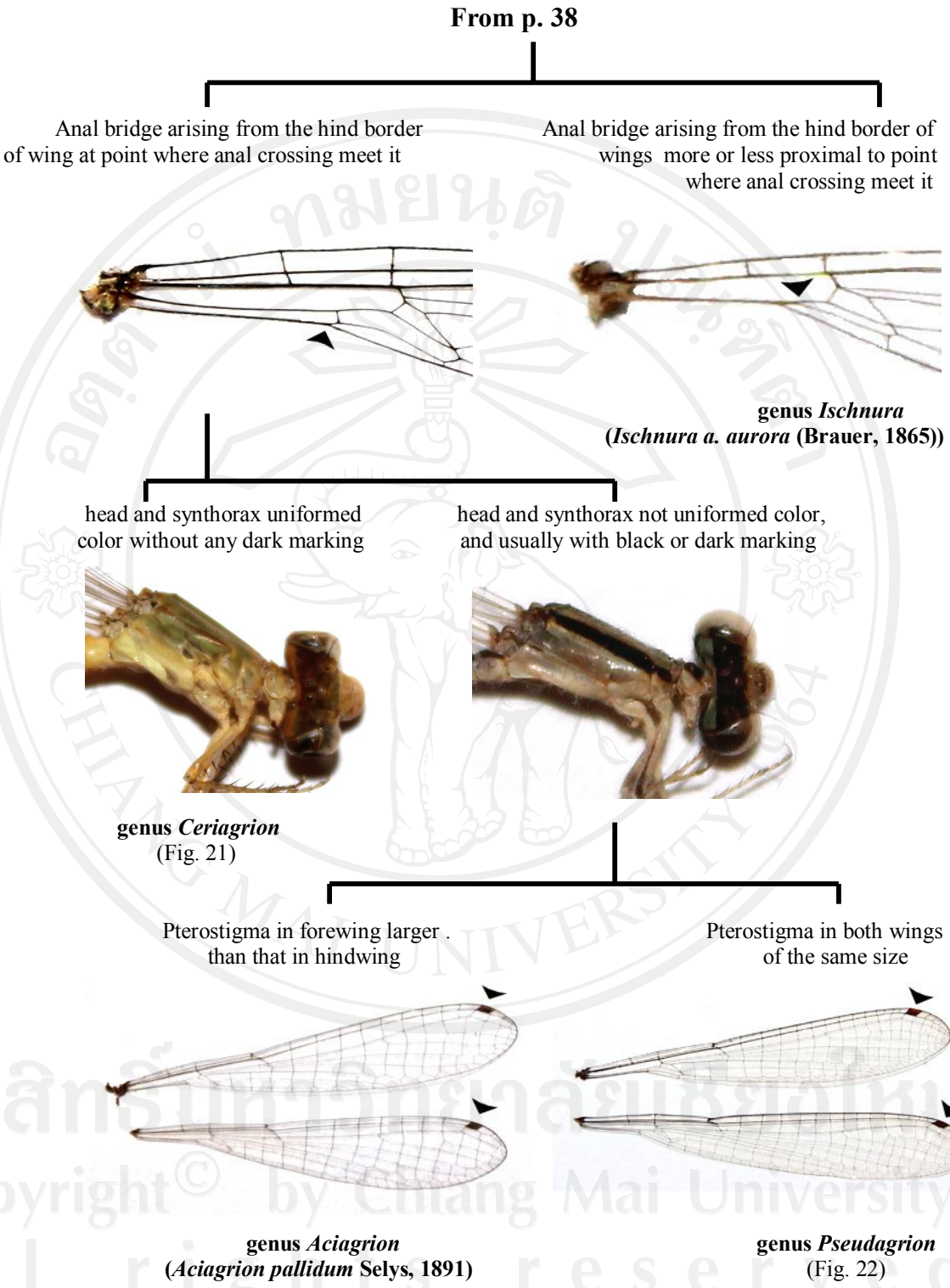


Fig. 19 Key to genera of family Coenagrion recorded in this study (continued).

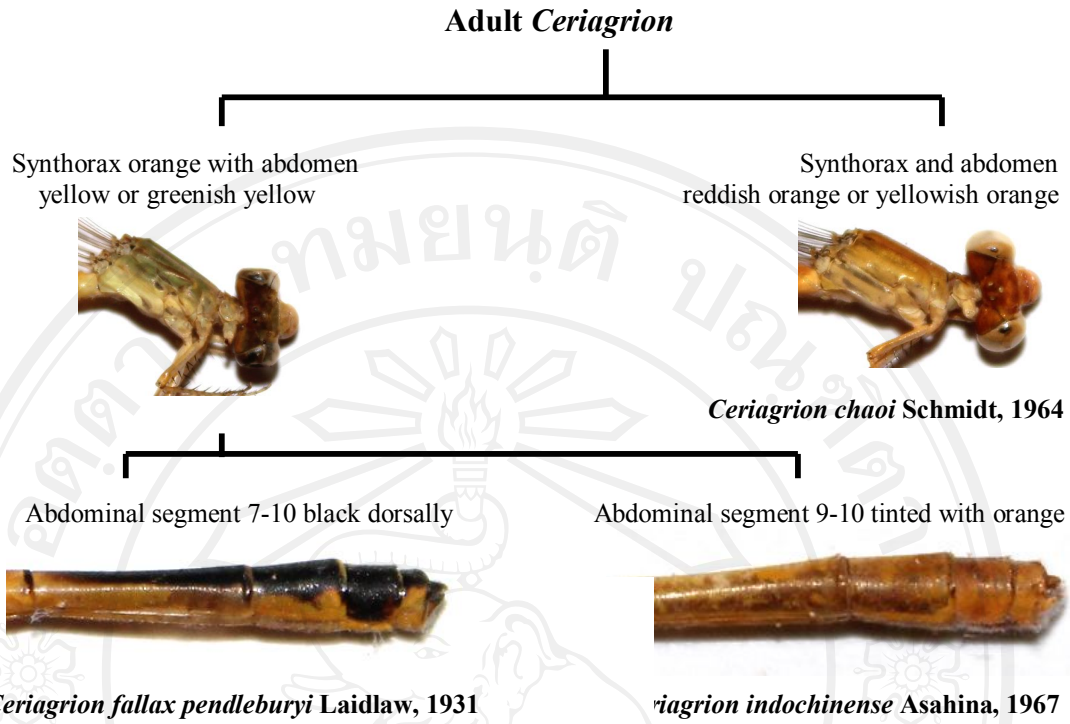


Fig. 20 Key to species of genus *Ceriagrion* recorded in this study.

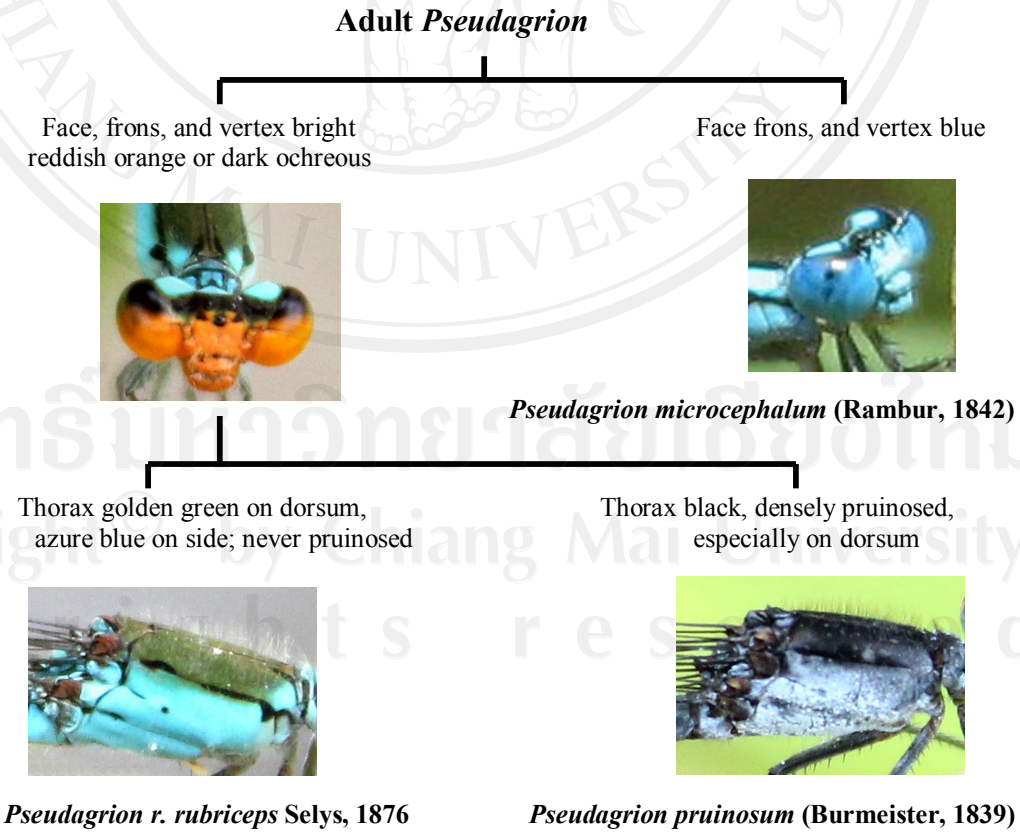


Fig. 21 Key to species of genus *Pseudagrion* recorded in this study.

4.5.12 Key to genera of family Platycnemididae recorded in this study

1. Wing petiolated to the level of anal crossing, so that anal bridge starts at level of ac on the wing margin……..……...……...… *Coeliccia*
1'. Wing petiolated before the level of anal crossing, thus anal bridge starts some distance proximal to anal crossing.……..……..…….. **2**

2. Postnodal crossvein numerous in forewing (17-20), costal side of quadrilateral in forewing shorter than the posterior side, three cells present between the outer side of quadrilateral and level of subnodus..... *Calicnemia*
2'. Postnodal crossvein less in number in forewing (9-17), costal side of quadrilateral of forewing nearly equal to posterior side; two cells present between outer side of quadrilateral and the level of subnodus ….…..*Copera*

4.5.13 Key to species of genus *Coeliccia* recorded in this study

1. Dorsum of synthorax entirely colored .....……..…… **2**
1'. Dorsum of synthorax marked with colored spots, or antehumeral stripe…**3**

2. Distal two abdominal segments and appendages reddish yellow; dorsum of synthorax wholly blue ….…*Coeliccia poungyi* Fraser, 1924
2'. Distal two abdominal segments and appendages yellowish white, dorsum of synthorax entirely orange yellow….*Coeliccia chromothorax* (Selys, 1891)

3. Two pairs of blue spots present……. *Coeliccia d. didyma* (Selys, 1863)
3'. Antehumeral stripes present ……..…….. **4**

4. Two pairs of blue narrow stripe present; abdomen and appendages all black ……..…….... *Coeliccia loogali* Laidlaw, 1932
4'. Three pairs of short blue stripe present; distal half of abdominal segment 9 to appendages dull orange yellow…… …… *Coeliccia doisuthepensis* Asahina, 1984

4.5.14 Key to species of genus *Calicnemia* recorded in this study

1. Abdomen dark azure blue; tip of inferior appendages slightly curve…... ……..…… *Calicnemia imitans* Lieftinck, 1948
1'. Abdomen red tinted with black at distal segment; tip of inferior appendages angulated ..…… *Calicnemia miles* (Laidlaw, 1917)

4.6.15 Key to species of genus *Copera* recorded in this study

1. Male superior appendages extremely short and blunt; inferior appendages longer than superior appendages and blunt; legs yellow with flattened meso- and metatibiae ……..…… *Copera marginipes* (Rambur, 1842)
1'. Male superior appendages short and pointed; inferior appendages longer than superior appendages and pointed; legs red with very poor flatten meso- and metatibiae ……..….. *Copera vittata* (Selys, 1863)

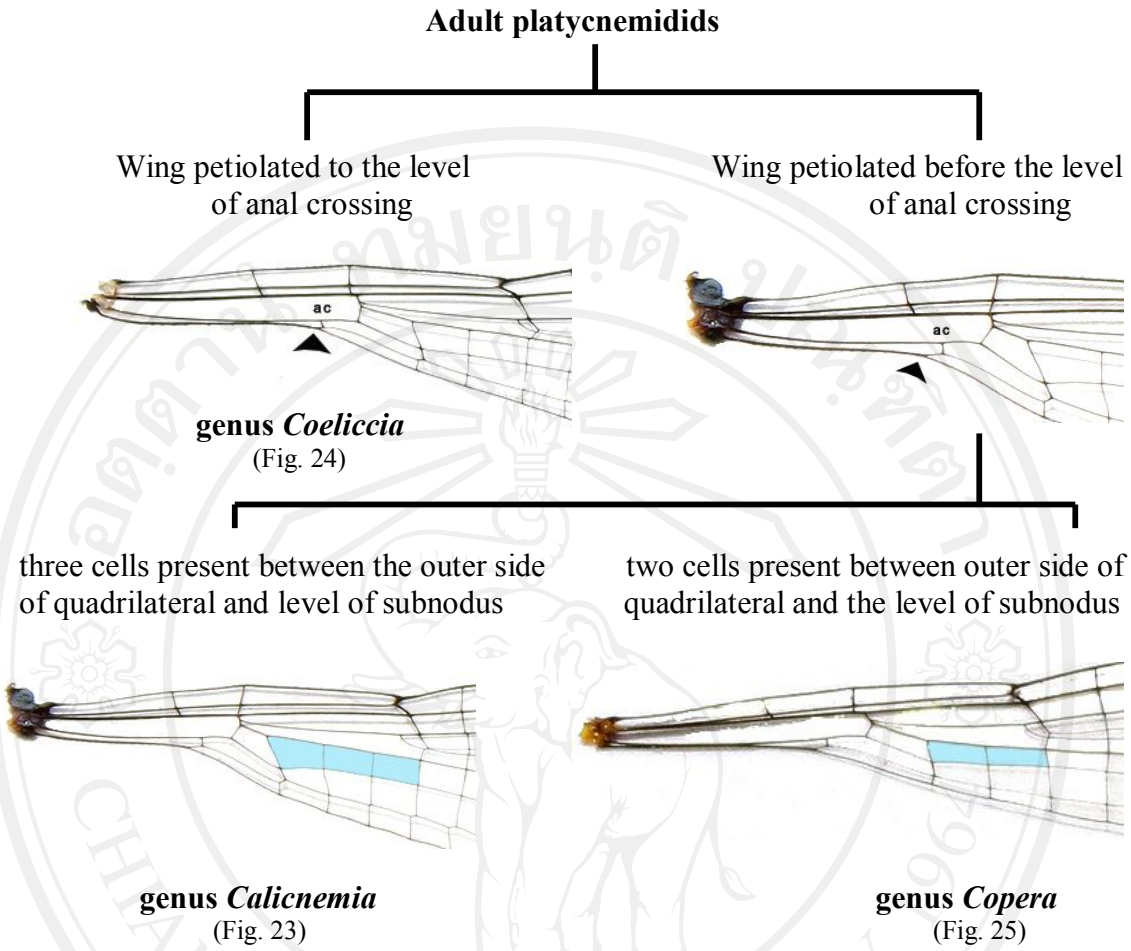


Fig. 22 Key to genera of family Platycnemididae recorded in this study.

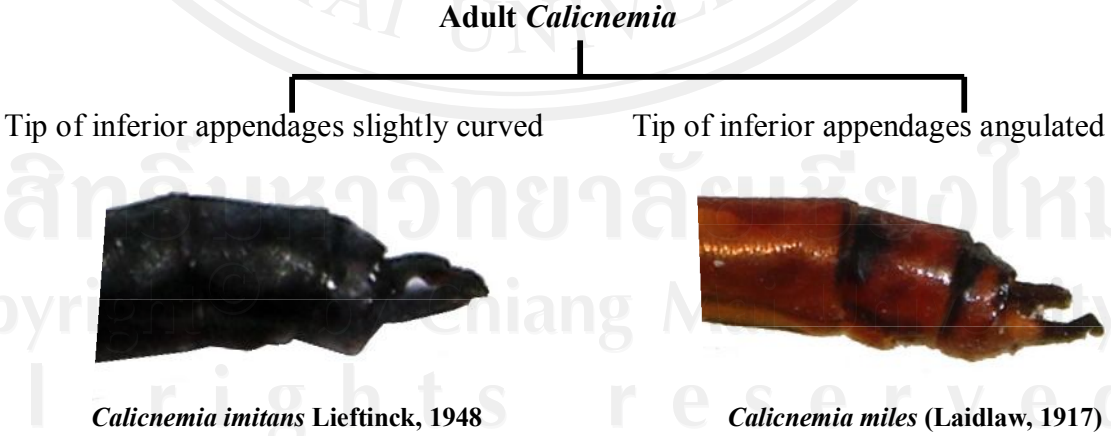


Fig. 23 Key to species of genus *Calicnemia* recorded in this study.

Adult *Coeliccia*

Dorsum of synthorax entirely colored

S9-10 and appendages reddish yellow

***Coeliccia poungyi* Fraser, 1924**

S9-10 and appendages yellowish white

***Coeliccia chromothorax* (Selys, 1891)**

Dorsum of synthorax marked with colored spots, or antehumeral stripes

Antehumeral stripes present

Two pairs of blue spots present

***Coeliccia didyma didyma* (Selys, 1863)**

Adomen and appendages all black

***Coeliccia loogali* Laidlaw, 1932**

Dtal half of abdominal segment 9 to appendages dull orange yellow

***Coeliccia doisuthepensis* Asahina, 1984**

Fig. 24 Key to species of genus *Coeliccia* recorded in this study.

Adult *Copera*

Legs yellow with flattened meso- and metatibiae

***Copera marginipes* (Rambur, 1842)**

legs red with very poor flatten meso- and metatibiae

***Copera vittata* (Selys, 1863)**

Fig. 25 Key to species of genus *Copera* recorded in this study.

4.6 Key to anisopteran families recorded in this study

1. Eyes well separated or close but not quite touching when viewed from above. If eyes fairly close, then large yellow banded species with auricles present on abdominal segment 2 of the male…….…….. **Gomphidae**

1'. Eyes broadly contiguous or at least touching viewed from above. If eyes just touching then medium-sized red or brownish species with male lacking auricles……..……**2**

2. Triangles similar in both wings, elongate along the wing axis with costal side much longer than basal side. Female always with well-developed ovipositor. Medium-sized to very large species……..……. **Aeshnidae**

2'. Triangles dissimilar. If elongate along the wing axis in hindwing, then elongate parallel to body in forewing. Female lacking ovipositor…….……...**3**

3. Ground color of thorax and abdomen almost always metallic. Most species with well-defined projection on the hind margin of the compound eyes. Male of most species with hindwing anal angle acute and auricles present laterally on segment 2 of abdomen. Male always with tibia keels on the inner (flexor) surface, at least on fore and hind legs. Small to large species ……**Corduliidae**

3'. Ground color of thorax mostly non-metallic and abdomen only very rarely metallic–more commonly dorsoventrally flattened and red or blue. Never with well-defined projection on hind margin of eyes–at most a marked sinuousness. Males without auricles and with anal angle of hindwing always rounded. Tibial keels never present on any legs. Tiny to large species….. **Libellulidae**

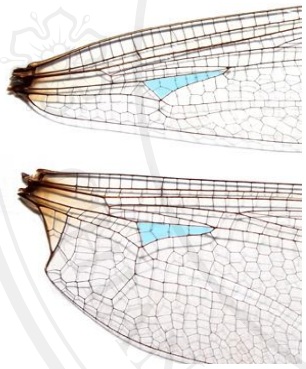
Adult anisopterans

Eyes broadly contiguous or at least touching but not quite touching

Eyes well separated or close

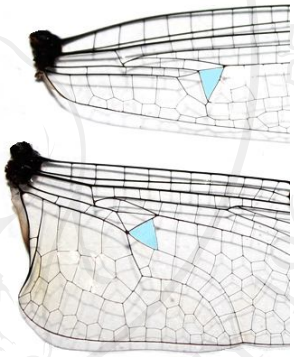
Family Gomphidae
(Fig. 27)

Triangles similar in both wings



Family Aeshnidae
(Fig. 28)

Triangles dissimilar in both wings



Male of most species with hindwing anal angle acute

Family Corduliidae
(Fig. 30)

Male with anal angle of hindwing always rounded

Family Libellulidae
(Fig. 32)

Fig. 26 Key to anisopteran families recorded in this study.

4.7 Key to genera and species of Anisoptera recorded in this study

4.7.1 Key to genera of family Gomphidae recorded in this study

1. Triangle cell, hypertriangle, subtriangle of forewing traversed or reticulated……..…….....…. **2**
1'. Triangle cell, hypertriangle, subtriangle of forewing always entire……..……..…….. **3**

2. Abdominal segment 8 widely dilated and with wing-like lateral projections; superior appendages acute at apex …….... *Ictinogomphus*
2'. Abdominal segment 8 not dilated; superior appendages obtuse at apex.. ……...… *Gomphidictinus*

3. At least 4 crossveins between sectors of arculus in forewing from arculus to bifurcation of Rs ……..…. **4**
3'. Usually only two (rarely three or four) crossveins between sectors of arculus in forewing from arculus to bifurcation of Rs…… **6**

4. Incomplete basal antenodal crossveins present in most wings…… **5**
4'. Incomplete basal antenodal crossveins always absent ….…… …… *Heliogomphus*

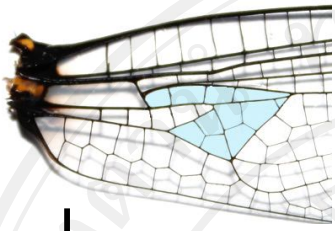
5. Pterostigma well braced ……..…… *Asiagomphus*
5'. Pterostigma not braced ……..…..…… *Leptogomphus*

6. Anal loop absent; anal triangle nearly always 3 celled ……..……...… **7**
6'. Anal loop present; anal triangle nearly always 4 celled.... *Paragomphus*

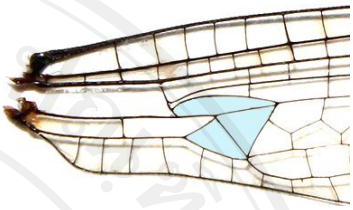
7. Pterostigma covered 4.0-4.5 cells …….... *Burmagomphus*
7'. Pterostigma covered 5.0-5.5 cells ……..…… *Anisogomphus*

Adult gomphids

Triangle, hypertriangle, subtriangle of forewing reticulated



Triangle, hypertriangle, subtriangle of forewing always entire



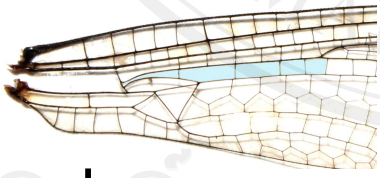
Abdominal segment 8 widely dilated

genus *Ictinogomphus*
(*Ictinogomphus decoratus melaenops* (Selys, 1858))

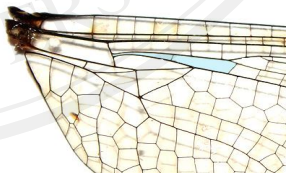
Abdominal segment 8 not dilated

genus *Gomphidictinus*
(*Gomphidictinus perakensis* (Laidlaw, 1902))

At least 4 crossveins between sectors of arculus to bifurcation of Rs in forewing

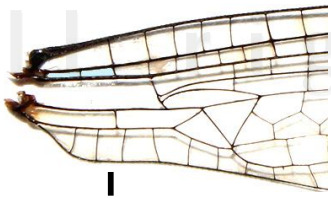


Usually only two crossveins between sectors of arculus to bifurcation of Rs



p. 49

Incomplete basal antenodal crossveins present in most wings



p. 49

Incomplete basal antenodal crossveins always absent

genus *Heliogomphus*
(*Heliogomphus selysi* Fraser, 1925)

Fig. 27 Key to genera of Gomphidae recorded in this study.

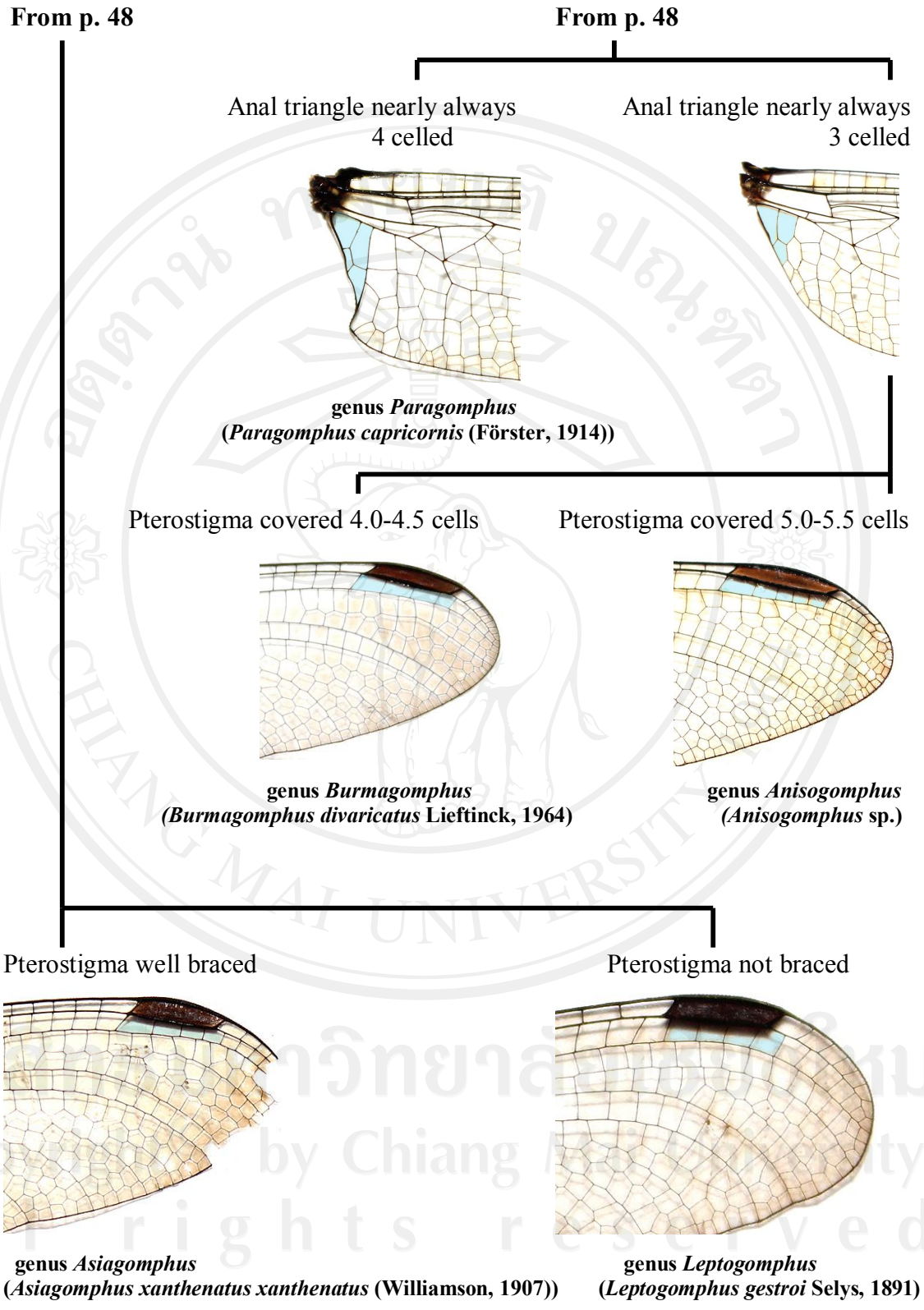


Fig. 27 Key to genera of Gomphidae recorded in this study (continued).

4.7.2 Key to genera of family Aeshnidae recorded in this study

1. Base of hindwing without a notch; tornus (postero-basal angle) of hindwing rounded in both sexes; anal triangle absent …..……... *Anax*

1'. Base of hindwing more or less deeply notched; tornus of hindwing angulated in the male; anal triangle always present ……..…….. **2**

2. Anal membrane large, extending on to base of wing; base of wing nearly as broad as the broadest part of the wing; base of quadrilateral in forewing nearer level of arculus than its own length….. *Polycanthagyna*

2'. Anal membrane nearly obsolete, not extending to base of the wing; base of wing much narrower than broadest part of the wing; base of quadrilateral as far from level of arculus as its own length……... *Gynacantha*

4.7.3 Key to species of genus *Anax* recorded in this study

1. Synthorax pale green barred with mat black; abdomen orange without colored spots ……..…….... *Anax immaculifrons* Rambur, 1842

1'. Synthorax pale green or bluish green without any broad markings; abdomen black with orange spots …….... *Anax guttatus* (Burmeister, 1839)

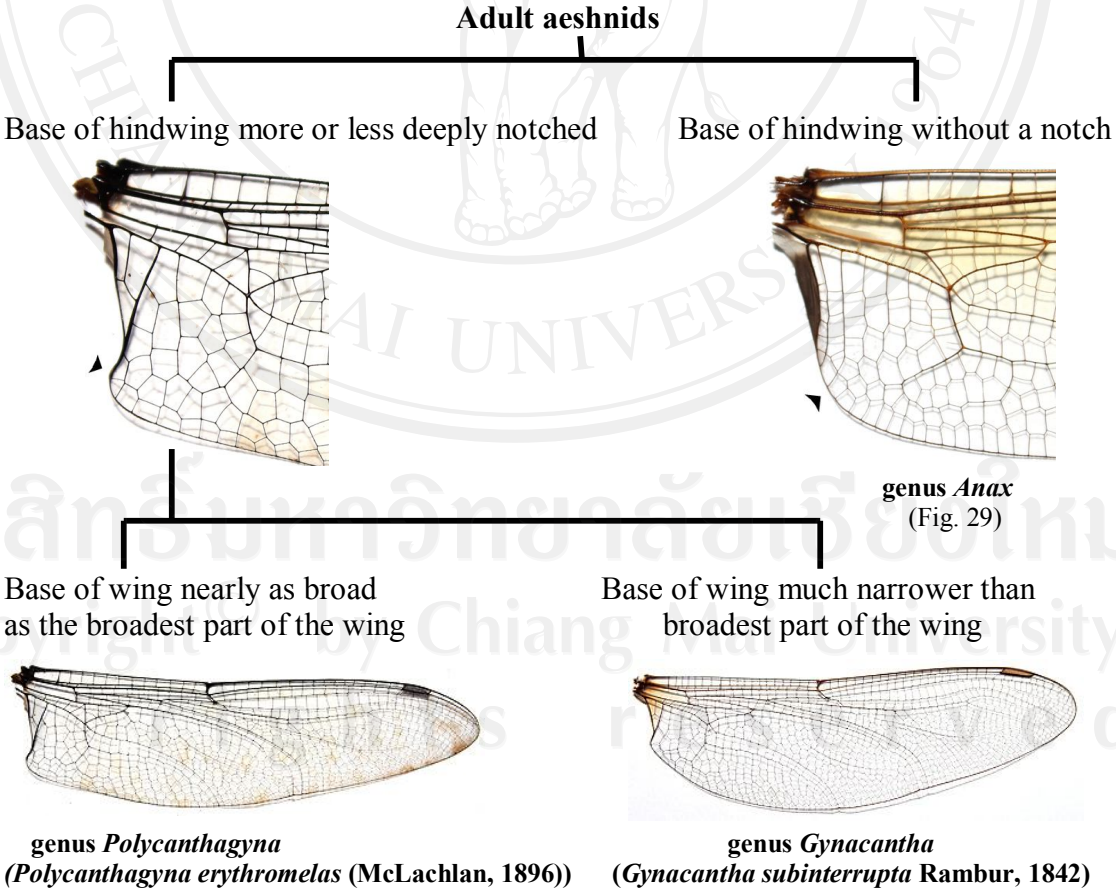


Fig. 28 Key to genera of family Aeshnidae recorded in this study.

Adult *Anax*

Abdomen orange without colored spots — Abdomen black with orange spots

***Anax immaculifrons* Rambur, 1842** — ***Anax guttatus* (Burmeister, 1839)**

Fig. 29 Key to species of genus *Anax* recorded in this study.

4.7.4 Key to genera of family Corduliidae recorded in this study

1. Quadrilateral of forewing commencing with two or more rows of cell…**2**
1'. Quadrilateral of forewing commencing with single row of cell....*Idionyx*

2. R_{4+5} and MA in hindwing markedly sinuous; the second space from anterior border of wing, immediately distal to nodus, without a long space free of crossvein……..……..…. *Macromia*
2'. R_{4+5} and MA in hindwing smoothly curved; the second space from anterior border of wing, immediately distal to nodus, with a long space free of crossvein ……..……..…….. *Macromidia*

4.7.5 Key to species of genus *Idionyx* recorded in this study

1. Male superior appendages smoothly attenuated to the end with recurved and pointed apical end; inferior appendages strongly recurved..... ……..……... *Idionyx selys* Fraser, 1926
1'. Male superior appendages slightly curved with a projection on subapical; inferior appendages longer and recurved with branched interior…… *Idionyx* sp. [nec. *optata* Selys, 1878]

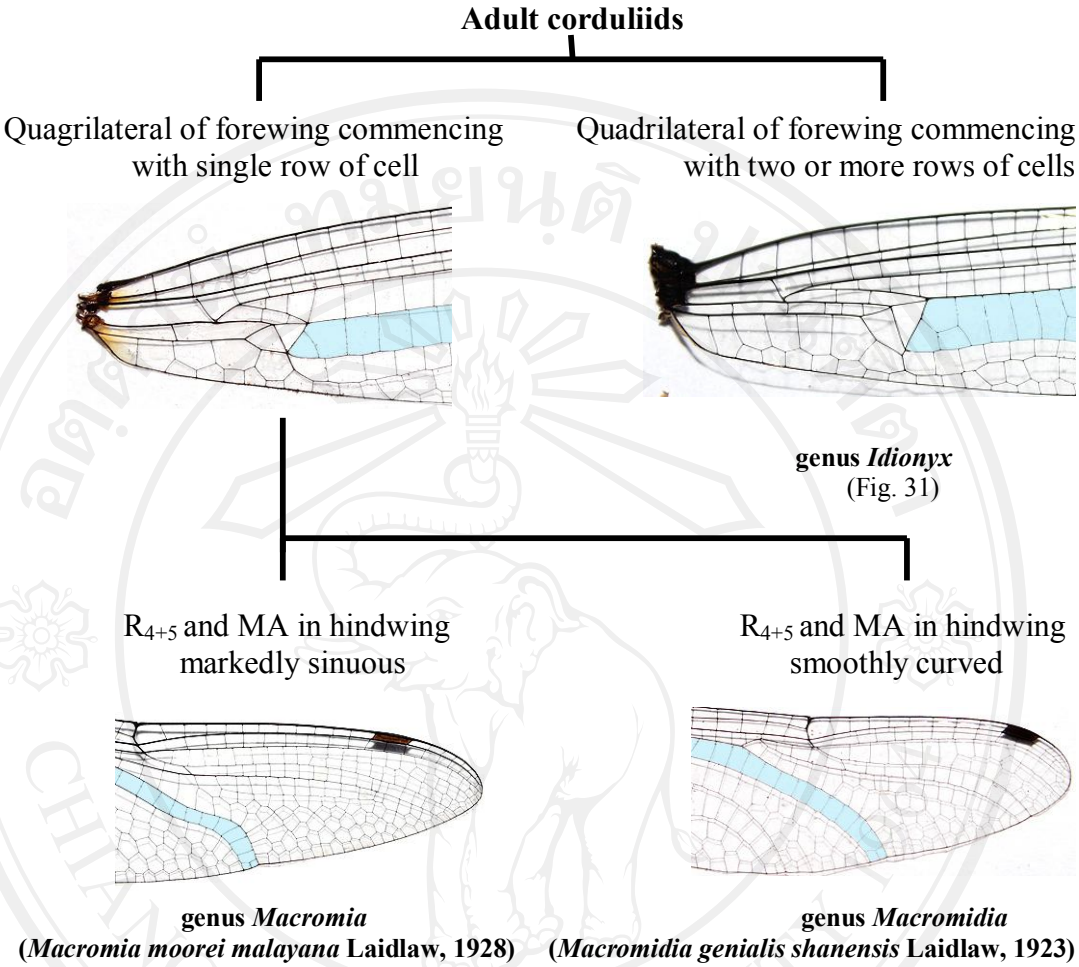


Fig. 30 Key to genera of family Corduliidae recorded in this study

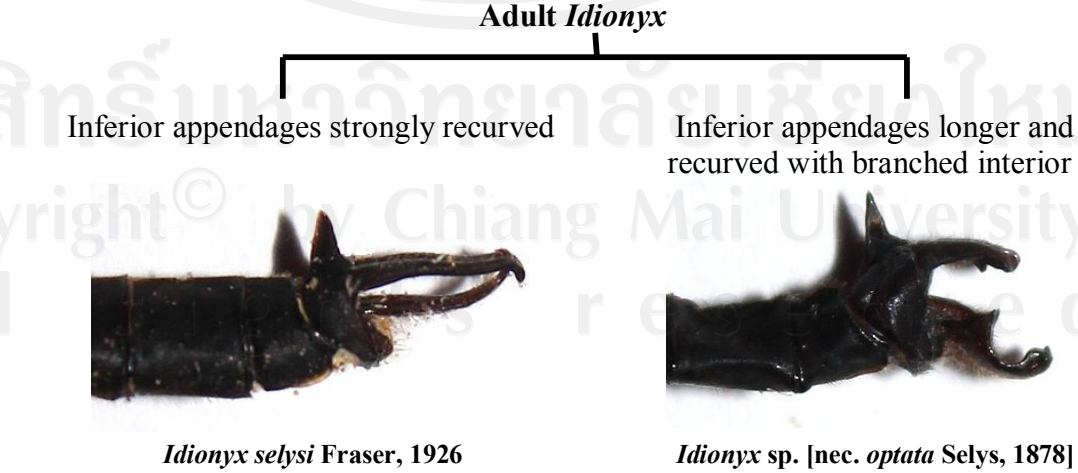


Fig. 31 Key to species of genus *Idionyx* recorded in this study.

4.7.6 Key to genera of family Libellulidae recorded in this study

1. Anal loop very small, consist of not more than 6 cells……..…… ……. *Hylaeothemis*
1'. Anal loop elongated, made up more than 6 cells…….. **2**

2. Synthorax metallic; tarsal craw-hooks equal in length to craws which, thus, appear bifid ……..…….…… *Zygonyx*
2'. Synthorax rarely metallic; tarsal craw-hooks shorter than craws and arising from the middle of the latter ……... **3**

3. Border of anal loop running on to meet posterior border of wing, apex of anal loop closed ……..…… *Tholymis*
3'. Border of anal loop converging and meeting before posterior border of wing, apex of anal loop open …… **4**

4. Distal antenodal crossvein complete …… **5**
4'. Distal antenodal crossvein incomplete …… **6**

5. Lobe of prothorax large and fringed with long hairs…..…… *Orthetrum*
5'. Lobe of prothorax small, inconspicuous, usually naked …… *Cratilla*

6. Lobe of prothorax large and fringed with long hairs…..… *Diplacodes*
6'. Lobe of prothorax small, inconspicuous, usually naked …… **7**

7. Sectors of arculus in forewing separated and diverging at origin ..... …….. *Rhyothemis*
7'. Sectors of arculus in forewing arising from a common and rather long stalk…….. **8**

8. Discoidal area with borders converging strongly at wing margin……. **9**
8'. Discoidal area with borders parallel or diverging at wing margin..…. **10**

9. Triangle cell in forewing very narrow, its costal side only about one fourth to one third the length of basal; IR_2 present between R_2 and R_3 ..... *Pantala*
9'. Triangle cell in forewing broader, its costal side about one half the length of basal; no IR_2 present between R_2 and R_3 ……..…... *Trithemis*

10. Triangle area in forewing adjacent to triangle cell only two cells wide.. ……..…… *Indothemis*
10'.Triangle area in forewing adjacent to triangle cell three or more cells wide……..**11**

11. Hindwing very broad at base and rather tapered at apex; pterostigma very short and unequal in fore- and hindwings …….. *Tramea*
11'.Hindwings not markedly wide at base and apex not markedly tapered; pterostigma variable and usually equal size in fore- and hindwings... **12**

12. More than 1 cubital crossvein in all wings ……..…. *Neurothemis*
12'.Only 1 cubital crossvein in all wings ……..… **13**

13. Red or ochreous species with basal or medial yellow markings on wing. …… **15**
13'.Variably colored and darker species, never or only partly red or ochreous ……..……..…**14**

14. Triangle in hindwing traversed with one crossvein …… *Potamarcha*
14'.Triangle in hindwing entire ……..…… *Pseudothemis*

15. Wings with small yellow basal markings; eyes only shortly contiguous; 9½ to 10½ antenodal crossveins in forewing ……..…. *Crocothemis*
15'.Wings with broad reddish yellow medial fascia; eyes broadly contiguous; 6½ to 7½ antenodal crossveins in forewings …… *Brachythemis*

4.7.7 Key to species of genus *Orthetrum* recorded in this study

1. Males colored red ……..… **2**
1'. Males colored brown or black with yellow markings; often pruinosed…**3**

2. Males bright red; frons bright red or yellow in front ..... ……..…..... *Orthetrum chrysis* (Selys, 1891)
2'. Males violaceous red; frons blue-black anteriorly ……..... ……..……....… *Orthetrum pruinosum neglectum* (Rambur, 1842)

3. Abdomen enormously swollen at base and then abruptly slimmed and compressed laterally to the end; black marked with greenish yellow, not pruinosed ……..... *Orthetrum sabina sabina* (Drury, 1770)
3'. Abdomen variable but never slim nor compressed laterally; mostly with pruinosed synthorax and abdomen ……..… **4**

4. Base of hindwing with a large black triangular marking ….……. ……..…….. *Orthetrum triangulare triangulare* (Selys, 1878)
4'. Base of hindwing without a black triangular marking ….……... ……..…… *Orthetrum glaucum* (Brauer, 1865)

4.7.8 Key to species of genus *Rhyothemis* recorded in this study

1. Wings marked with black and amber yellow …… **2**
1'. Wings marked with black only ……. *Rhyothemis plutonia* Selys, 1883

2. Wings widely different in both sexes; male with whole wings tinted yellow, forewing with black spot at nodus, triangle cell, apex, and middle of R_3; female with broader, shorter wings, forewing hyaline from nodus to apex, basal half with broad black marking……. ……..…..... *Rhyothemis variegata variegata* (Linnaeus, 1763)

2'. Wings similar in shape and markings in both sexes; male with apices of all wings opaque, a nodal spot in hindwing and two short, broad, basal fascia in hindwing; all female with black apices to wing……..…... …… *Rhyothemis phyllis phyllis* (Sulzer, 1776)

4.7.9 Key to species of genus *Trithemis* recorded in this study

1. Base of hindwing with a small dark brown spot; wing veins black; synthorax and abdomen violaceous black……..…… ……..……...… *Trithemis festiva* (Rambur, 1842)

1'. Base of hindwing with a small reddish brown spot; wing veins crimson; synthorax and abdomen crimson... *Trithemis aurora* (Burmeister, 1839)

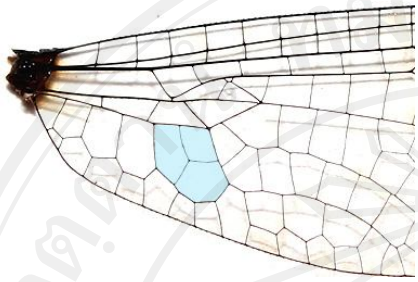
4.7.10 Key to species of genus *Neurothemis* recorded in this study

1. Wings dark reddish brown from base to about middle of pterostigma, apex of wings also narrowly opaque brown to partly enclose clear window in each wing at apex …….. *Neurothemis fulvia* (Drury, 1773)

1'. Wings tinted with pale yellow or golden yellow at base..... …… *Neurothemis intermedia atalanta* Ris, 1919

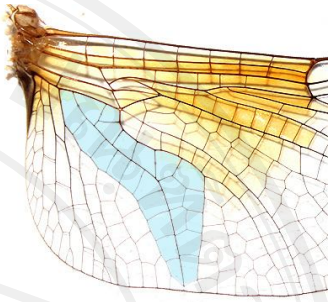
Adult libellulids

Anal loop very small, consist of not more than 6 cells



genus *Hylaeothemis*
(*Hylaeothemis clementia* Ris, 1909)

Anal loop elongated, made up more than 6 cells

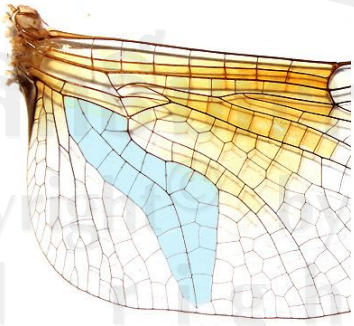


Synthorax rarely metallic

Synthorax metallic

genus *Zygonyx*
(*Zygonyx iris malayana* (Laidlaw, 1902))

Apex of anal loop closed



genus *Tholymis*
(*Tholymis tillarga* (Fabricius, 1798))

Apex of anal loop open

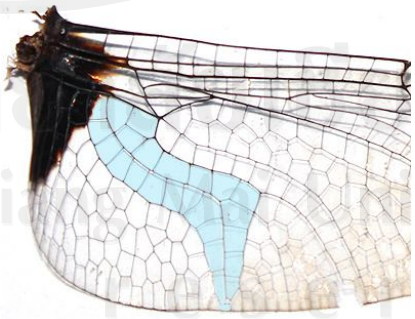


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Fig. 32 Key to genera of family Libellulidae recorded in this study.

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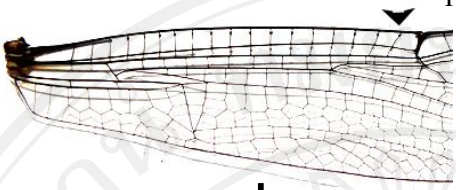
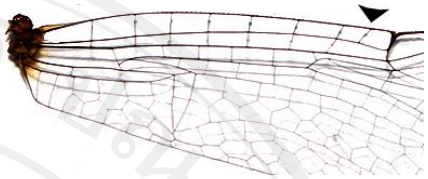
Distal antenodal crossvein complete



Distal antenodal crossvein incomplete



Lobe of prothorax large and fringed with long hairs

genus *Orthetrum*
(Fig. 33)

Lobe of prothorax small, inconspicuous, usually naked

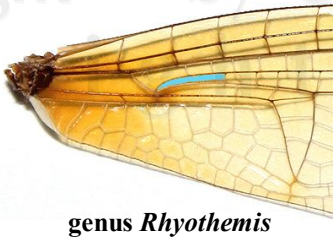
genus *Cratilla*
(*Cratilla lineata calverti* Förster, 1903)

Lobe of prothorax large inconspicuous, usually naked

Lobe of prothorax small, and fringed with long hairs

genus *Diplacodes*
(*Diplacodes trivialis* (Rambur, 1842))

Sectors of arculus in forewing separated and diverging at origin



genus *Rhyothemis*
(Fig. 34)

Sectors of arculus in forewing arising from a common and rather long stalk

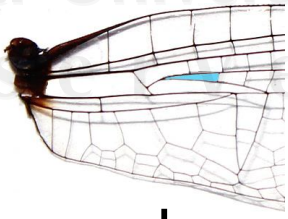


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Fig. 32 Key to genera of family Libellulidae recorded in this study (continued).

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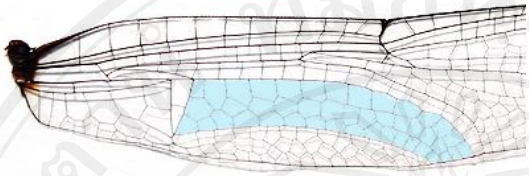
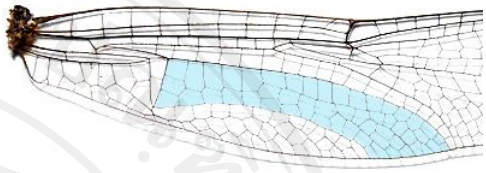
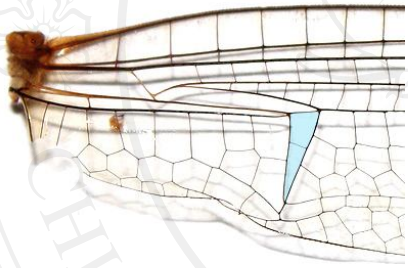
Discoidal area with borders converging strongly at wing margin



Discoidal area with borders parallel or diverging at wing margin

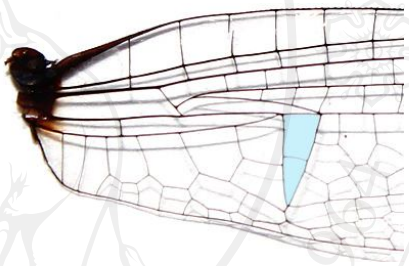


Triangle cell in forewing very narrow



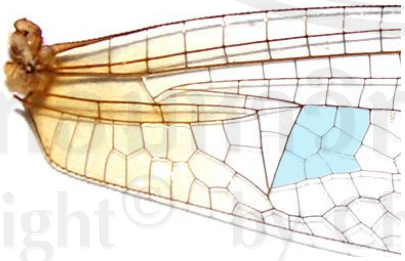
genus *Pantala*
(*Pantala flavescens* (Fabricius, 1798))

Triangle cell in forewing broader

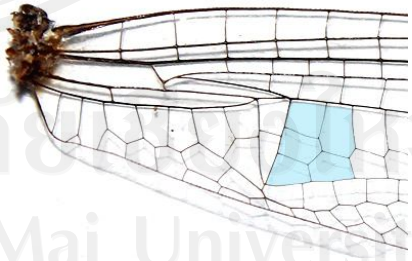


genus *Trithemis*
(Fig. 35)

Triangle area in forewing adjacent to triangle cell three or more cells wide



Triangle area in forewing adjacent to triangle cell only two cells wide



genus *Indothemis*
(*Indothemis carnatica* (Fabricius, 1798))

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Fig. 32 Key to genera of family Libellulidae recorded in this study (continued).

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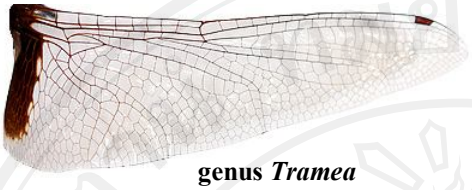
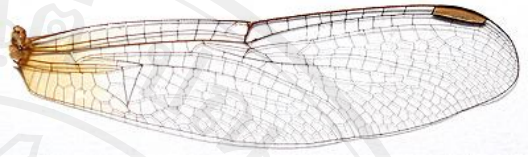
Hindwing very broad at base and rather tapered at apex

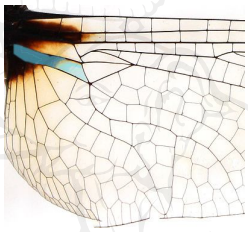


genus *Tramea*
(*Tramea transmarina euryale* Selys, 1878)

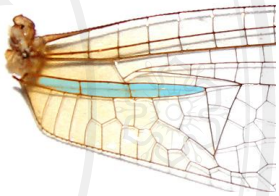
Hindwings not markedly wide at base and apex not markedly tapered



Only 1 cubital crossvein in all wings



> 1 cubital crossvein in all wings



genus *Neurothemis*
(Fig. 36)

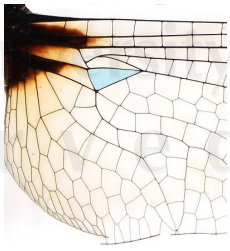
Red or ochreous species with basal or medial yellow markings to wings

Variably colored and darker species, never or only partly red or ochreous

Triangle in hindwing traversed

genus *Potamarcha*
(*Potamarcha congener* (Rambur, 1842))

Triangle in hindwing entir



genus *Pseudothemis*
(*Pseudothemis jorina* Förster, 1904)

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Fig. 32 Key to genera of family Libellulidae recorded in this study (continued).

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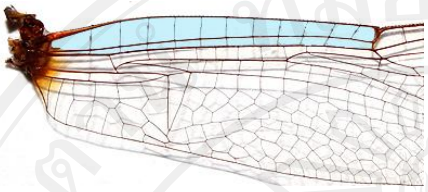
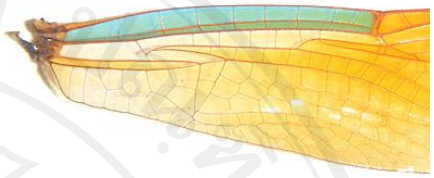
9½ to 10½ antenodal crossveins in forewing



genus *Crocothemis*
(*Crocothemis sabina servilia* (Drury, 1770))

6½ to 7½ antenodal crossveins in forewings



genus *Brachythemis*
(*Brachythemis contaminata* (Fabricius, 1793))

Fig. 32 Key to genera of family Libellulidae recorded in this study (continued).

Adult *Orthetrum*

Males colored brown or black with yellow markings; often pruinosed

Males colored red

Males bright red; frons bright red or yellow in

***Orthetrum chrysis* (Selys, 1891)**

Males violaceous red; frons blue-black anteriorly

***Orthetrum pruinosum neglectum* (Rambur, 1842)**

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Fig. 33 Key to species of genus *Orthetrum* recorded in this study.

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Abdomen variable but never slim nor compressed laterally

Abdomen enormously swollen at base and then abruptly slimmed and compressed laterally to the end

***Orthetrum sabina sabina* (Drury, 1770)**

Base of hindwing with a large black triangular marking

Base of hindwing without a black triangular marking

***Orthetrum triangulare triangulare* (Selys, 1878)** ***Orthetrum glaucum* (Brauer, 1865)**

Fig. 33 Key to species of genus *Orthetrum* recorded in this study (continued).

Adult *Rhyothemis*

Wings marked with black and amber yellow

Wings marked with black only

***Rhyothemis plutonia* Selys, 1883**

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Fig. 34 Key to species of genus *Rhyothemis* recorded in this study.

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All female with black apices to wing

Forewing hyaline from nodus to apex, basal half with broad black marking

***Rhyothemis phyllis phyllis* (Sulzer, 1776)**

***Rhyothemis variegta variegata* (Linnaeus, 1763)**

Fig. 34 Key to species of genus *Rhyothemis* recorded in this study (continued).

Adult *Trithemis*

Base of hindwing with a small dark brown spot

Base of hindwing with a small reddish brown spot

***Trithemis festiva* (Rambur, 1842)**

***Trithemis aurora* (Burmeister, 1839)**

Fig. 35 Key to species of genus *Trithemis* recorded in this study.

Adult *Neurothemis*

Wings dark reddish brown from to about middle of pterostigma

Wings tinted with pale yellow or golden yellow at base

***Neurothemis fulvia* (Drury, 1773)**

***Neurothemis intermedia atalanta* Ris, 1919**

Fig. 36 Key to species of genus *Neurothemis* recorded in this study