SPECIES DIVERSITY OF ODONATES IN INYA LAKE AND KANDAWGYI LAKE ENVIRONS, YANGON REGION

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Abstract

The species composition, relative abundance, species diversity and evenness of the odonates from Inya Lake and Kandawgyi Lake environs of Yangon Region were assessed from February 2024 to July 2024. The species were collected weekly from three different habitat types; grasslands, wetlands and shrub lands. A total of 1107 individuals of 15 species belonging to 12 genera under 3 families and 2 suborders were recorded from Inya Lake and 1066 individuals of 12 species belonging to 12 genera under 3 families and 2 suborders were recorded from Kandawgyi Lake environs. The highest recorded species from Inya Lake environs was *Crocothemis erythraea* and Kandawgyi Lake environs was *Brachythemis contaminata*. *Ischnura aurora* from the family Coenagrionidae was the lowest recorded species of both Inya Lake and Kandawgyi Lake environs. According to the observation, the diversity and evenness of odonates from Inya Lake environs were greater than Kandawgyi Lake environs. The wing venation of *Brachythemis contaminata* and *Crocothemis erythraea* were analyzed and their unique structures under Scanning Electron Microscope (SEM) were also described in the present study.

Keywords: odonates, species diversity, environs, individuals, evenness, venation, SEM

Introduction

Insects, one of the largest group of arthropods are the most numerous and diverse organisms on the earth. They have many kinds of interactions with humans and other forms of life on earth. There are 29 orders of insects within the class Insecta and most of which can be found within forest ecosystems (Redak, 2023). They may be found in almost all environments, even though a small number of species occur in the oceans. They have invaded every niche, except the oceanic benthic zone (Grimaldi and Engel, 2005). Insect identification is an increasingly common hobby, with butterflies and dragonflies being the most popular (Gullan and Cranston, 2014).

Pterygota is a subclass of insects that includes the winged insects. The Odonata is a good candidate as the oldest living member of the Pterygota (Shagufta, 2017). Odonates are an extremely primitive and ancient group of insects around 300 million years ago (Grimaldi and Engel, 2005). Based on morphology, the order Odonata is divided into three suborders: Anisoptera, Zygoptera and Anisozygoptera (Subramanian and Babu, 2018). Odonata contained 5956 described species as of 2010 (39 families, 659 genera). 3012 species belong to the suborder Anisoptera (348 genera, 11 families), 2942 to the suborder Zygoptera (309 genera, 27 families) and 2 to the Anisozygoptera (Suhling *et al.*, 2015).

Odonates are notable for the beauty and brilliance of their coloration (Richards and Davies, 2013). They are typically large and active by day. They are observed near lakes, ponds, rivers, streams, canals of all sizes and all over the marshy places (Ameilia *et al.,* 2006). The Anisopteran are larger and more robust than Zygopteran.

Adult odonates have two pairs of elongate and transparent wings. Their wings are mainly composed of veins and membranes (Zhang *et al.,* 2018). Dragonflies spread their wings when

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they are resting but damselflies hold together dorsally over the thorax and abdomen when at rest (Berger, 2004). In Anisoptera, forewings and hindwings are dissimilar in form and venation. Their hindwings are distinctively broader at the base than the forewings. However, forewings and hindwings of Zygoptera are closely similar in form and venation. Most possess hyaline wings, but there are certain groups in which they are conspicuously coloured (Orr *et al.*, 2004). Dragonflies tend to be strong, fast fliers, and their flight appears purposeful, directed. Damselflies look weak and a little aimless in flight; they are more likely to flit and flutter (Richards and Davies, 2013). In the past, wing venation was used as the main guide for classifying the order Odonata. The details of venation are very important in identification and classification (Suhling *et al.*, 2015).

Odonates are hemimetabolous and amphibiotic insects which inhabit all kinds of freshwater habitats. The immature stages of the odonates are totally aquatic. Their mature stages have highly specific habitat preferences (Miguel *et al.,* 2017). Odonates have a wide distribution among habitats, but specific species occur in each habitat, thus making them useful as indicators of environmental quality (Junior et.al, 2015). They are of great importance in destroying noxious flies and mosquitoes, blackflies and other blood sucking flies, as well as the smaller moths which are regarded as pests and act as an important biocontrol agent of these harmful insects (Fraser, 1933). The sudden absence of some odonates may indicate rapid environmental degradation and we can monitor environmental changes by observing odonate populations (Kannagi *et al.,* 2016).

Odonates are reliable indicators of the ecological integrity for ecosystem structures, the ecological quality of the land-water-interface and the connectivity of aquatic ecosystems to other landscape units (Chovanec and Raab, 1997). Since larvae inhabits in aquatic, their diversity and abundance are positively correlated with overall aquatic macro-invertebrate diversity and abundance. Aquatic macro-invertebrates have frequently been used as biological indicators in lotic environments but much less commonly so in lentic habitats. Dragonflies and damselflies (Order: Odonata) satisfy most selection criteria for lentic bio-indicators of grazing impacts (Lee Foote and Rice Hornung, 2005). The main objectives for the present study were to identify and record the occurrence of odonates and their abundance, to determine the species composion, relative abundance, species diversity and evenness of odonates from Inya and Kandawgyi Lake environs and to analyse the wing venations of the two most dominant dragonflies from the recorded odonates under Scanning Electron Microscope (SEM).

Materials and Methods

The odonates (both dragonflies and damselflies) were collected from Inya Lake and Kandawgyi Lake environs which are located at Yangon Region, Myanmar. Inya Lake is situated at north latitude 16°50'25" and east longitude 96°08'27". Kandawgyi Lake is located at north latitude 16°47'40" and east longitude 96°09'54". For the observation, Inya Lake environs were divided into two study sites and also two from Kandawgyi Lake environs. The two study sites from Inya Lake environs were Inya Park and Myanmar Rowing and Canoeing Federation. Inya Park is in front of Yangon University of Economics and near University of Yangon. Myanmar Rowing and Canoeing Federation is in front of Yadanar Hall, University of Yangon. It is only 3 miles away from Inya Park. From Kandawgyi Lake environs, the odonates were recorded near the Western Park Royal Restaurant and in front of Café Garden Bristo at Kandawgyi Park during

the study period. Both of them are in the Kandawgyi Natural Garden situated on the Bahan road (Fig. 1).

A. Location maps of the study sites in Inya Lake environs

B. Location maps of the study sites in Kandawgyi Lake environs

Figure. 1. Location maps of the study sites in Inya Lake and Kandawgyi Lake environs (Sources: Google Earth, 2024)

Specimens collection

The specimens were collected weekly from February 2024 to July 2024. The three habitat types (grasslands, wetlands and shrub lands) were chosen for the specimen collection based on the odonates favorable habitats (Plate 1). Since odonates are diurnal, the specimens were collected between 09:00 A.M and 12:00 A.M on every sampling day. The specimens were collected from an area of approximately 50m× 25m at each site. Near the water edges, collections were made within an area of about 50m× 2m (1m along the edge and 1m extending into the water). Each site required one and a half hours for specimen collection. They were collected by using insect sweep net and put them in the plastic containers with slotted covers. Some of the specimens were sacrificed by gentle squeezing of their thorax with thumb and index finger, without giving them chances to struggle and break wings. To avoid mechanical injuries, the sacrificed specimens were kept in the triangular envelopes for later detailed studies. The habitat types of the observed specimens were recorded on the containers along with the date of collection.

Grasslands Wetlands Shrub lands Grasslands Wetlands Shrub lands

A. Various habitat types of Inya Lake environs

B. Various habitat types of Kandawgyi Lake environs

Plate 1 Various habitat types of Inya Lake and Kandawgyi Lake environs

Identification of the specimens

The collected specimens were examined under stereo microscope in the microscopy laboratory, University of Yangon and their general morphologies, coloration, abdomen length and wingspan were described with scaled photographs. The identification of the specimens was followed by Fraser (1933,1934 & 1936).

Preparation of wings for Electron Microscopy

The unique structures of the selected dragonflies's wings were observed in the Universities' Research Center (URC), located in the University of Yangon. The wings were needed to dry and clean before scanning for electron microscopy. Subsequently, three sections of each wing were cut to fit on the sample holder and put the carbon double tape on the sample holder together with the sections of wings. The samples' surface was coated with a thin film of proper material, gold (Au) to achieve high-resolution and clear images. Then the samples were put into SEM (Zeiss EVO 18) and observed pterostigma, node, vein, cells and spike on the vein at different magnification. The venations of wings were described according to Fraser (1933 and 1936).

Data analysis

Species compositions of the recorded odonates were calculated after Thursfield, 1995.

Species composition = Number of species in each order/ family / Total number of species recorded * 100%

The relative abundance (RA) of the recorded species was calculated by using formula (Kumar and Sivaperuman, 2005).

Abundance categories:

- Rare = (0.1-2.0)
- Uncommon = (2.1-4.0)
- Frequent = (4.1-6.0)
- Common = (6.1-8.0)
- Abundant= (8.1-above)

The species diversity for Inya Lake and Kandawgyi Lake environs was determined by using Shannon Diversity Index "H'" (Shannon and Weiner,1949).

$H' = -\sum (Pi \ln Pi)$

Where, $Pi = ni/N$

H' = Shannon diversity index

Pi = Proportion of individuals of i-th species in a whole community

ni = Total numbers of individuals belonging to i-th species

N = Total number of individuals belonging to the sampled population

ln = Natural logarithm

Σ = sum symbol

*The higher the (H'), the greater the diversity.

The evenness of the recorded species was calculated by using Pielou's evenness index(J).

$J = H' / H_{max}$

Where, J = Pielou's Evenness index

H' = Shannon-Wiener index

H_{max} = ln S

S = Total number of species

*The values are between 0-1. When the value is getting closer to 1, it means that the individuals are distributed equally.

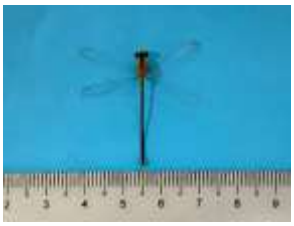
Results

A total of 2173 individuals of 18 species (12 dragonfly and 6 damselfly species), 15 genera, 3 families and two suborders of odonates were recorded from Inya lake and Kandawgyi lake environs from February 2024 – July 2024 (Table 1). Only 9 species were recorded in both Inya and Kandawgyi Lake environs (Plate 2).

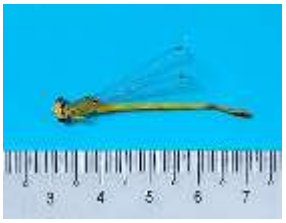
Table 4.1 Recorded odonate species found in Inya Lake and Kandawgyi Lake Environs

Sr. no.	Suborder	Family	Species	Common Name	Inya	Kandawgyi
1.	Anisoptera	Libellulidae	*Acisoma panorpoides*	Trumpet tail	-	+
2.			*Brachythemis contaminata*	Ditch jewel	+	+
3.			*Crocothemis erythraea*	Scarlet dragonfly	+	+
4.			*Diplacodes trivialis*	Ground skimmer	+	+
5.			*Libellula saturata*	Flame skimmer	+	+
6.			*Neurothemis tullia*	Pied paddy skimmer	+	-
7.			*Orthetrum pruinosum*	Crimson tail marsh hawk	+	+
8.			*Orthetrum sabina*	Slender skimmer	+	-
9.			*Pseudothemis jorina*	Banded skimmer	+	+
10.			*Rhyothemis phyllis*	Yellow-striped flutter	+	-
11.			*Tholymis tillarga*	Coral-tailed cloudwing	+	-
12.		Gompidae	*Progomphus obscurus*	Common sanddragon	+	+
13.	Zygoptera	Coenagrionidae	*Agriocnemis pygmaea*	Pygmy dartlet	+	+
14.			*Ceriagrion coromandelianum*	Coromandal marsh dart	-	+
15.			*Enallagma antennatum*	Rainbow bluet	-	+
16.			*Ischnura aurora*	Golden dartlet	+	+
17.			*Ischnura elegans*	Common bluetail	+	-
18.			*Ischnura senegalensis*	Marsh bluetail	+	-
Total Number of species					15	12

+ (present) ; - (absent)



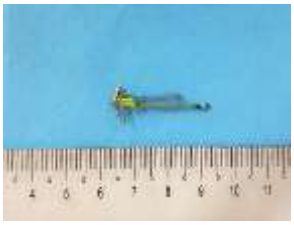
A. *Agriocnemis pygmaea*



B. *Ceriagrion coromandelianum*

C. *Enallagma antennatum*

D. *Ischnura aurora*



E. *Ischnura elegans*

F. *Ischnura senegalensis*

G. *Progomphus obscurus*

H. *Acisoma panorpoides*

I. *Crocothemis erythraea*

J. *Diplacodes trivialis*

K. *Brachythemis contaminata*

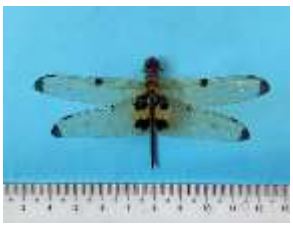
L. *Libellula saturata*

M. *Neurothemis tullia*

N. *Orthetrum pruinosum*

O. *Orthetrum sabina*

P. *Pseudothemis jorina*



Q. *Rhyothemis phyllis*

R. *Pseudothemis jorina*

Plate 2 Recorded damselfly and dragonfly species

Species composition of odonates found in Inya Lake and Kandawgyi environs

A total of 1107 individuals of 15 species, 12 genera, 3 families and two suborders of odonates (dragonflies and damselflies) were recorded from Inya Lake environs and 1066 individuals of 12 species belonging to 12 genera under three families and two suborders of dragonflies and damselflies were recorded from Kandawgyi Lake environs during study period. 85 individuals of damselflies belonging to family Coenagrionidae and 1022 individuals of dragonflies belonging to family Gomphidae and Libellulidae were recorded from Inya Lake environs. 67 % of the recorded species were from the family Libellulidae, 6 % from Gomphidae and 27 % from Coenagrionidae (Fig. 2). A total of 63 individuals of damselflies under family Coenagrionidae and 1003 individuals of dragonflies under family Gomphidae and Libellulidae were recorded from Kandawgyi Lake environs. 59% of the recorded odonates were from the family Libellulidae, 8% from Gomphidae and 33% from Coenagrionidae in Kandawgyi Lake environs. Coenagrionidae (Fig. 3). Family Libellulidae from suborder Anisoptera was the major component of odonates community in both Inya Lake and Kandawgyi Lake environs.

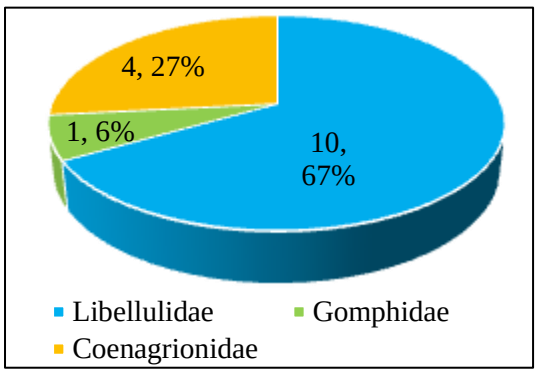


Figure. 2. Percentage of recorded odonate species with respective families in Inya Lake environs

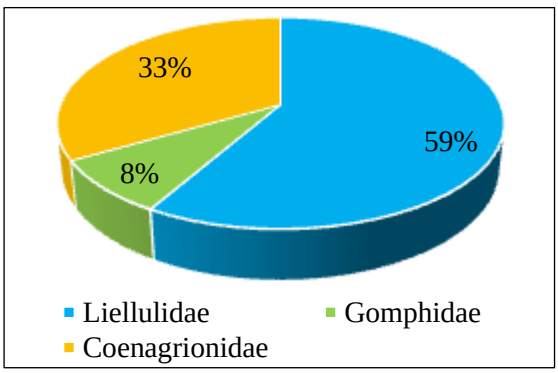


Figure. 3. Percentage of recorded odonate species with respective families in Kandawgyi Lake environs

Habitat types of the odonates found in Inya Lake and Kandawgyi Lake environs

Out of 1107 individuals, 398 individuals of 15 species were recorded in grasslands. 388 of 12 species were collected in wetlands and 321 of 7 species were collected from shrub lands from Inya Lake environs. *Crocothemis erythraea* was the most collected species found in grasslands and shrub lands. *Brachythemis contaminata* was the most recorded species found in wetlands compared with other species. The least collected species from grasslands, wetlands and shrub lands are *Pseudothemis jorina, Orthetrum sabina* and *Tholymis tillarga* respectively. *Neothemis tullia* from suborder Anisoptera and *Ischnura aurora* from the suborder Zygoptera were only found in grasslands (Table 2). In Kandawgyi Lake environs, among 1066 individuals, 386, 380, 300 individuals were recorded in grasslands, wetlands and shrub lands respectively. Only 8 species were found in shrub areas of Kandawgyi Lake environs. The most recorded species found in grasslands and shrub lands was *Crocothemis erythraea* from the family Libellulidae. *Brachythemis contaminata* also from the family Libellulidae was the most dominant species found in wetlands. *Ischnura aurora* from the suborder Zygoptera was the least dominant

species found in grasslands and shrub areas. Meanwhile *Ceriagrion coromandelianum* from the family Coenagrionidae was the least dominant species recorded in wetlands. *Pseudothemis jorina* from suborder Anisoptera was observed exclusively in wetlands (Table 3).

Table 2 Habitat types of recorded odonates species from Inya Lake environs

Sr. no.	Suborder	Family	Species	Habitat types		
				Grasslands	Wetlands	Shrub lands
1.	Anisoptera	Libellulidae	*Brachythemis contaminata*	58	82	68
2.			*Crocothemis erythraea*	89	45	98
3.			*Diplacodes trivialis*	47	14	56
4.			*Libellula saturata*	46	69	33
5.			*Neurothemis tullia*	12	-	-
6.			*Orthetrum pruinosum*	63	89	50
7.			*Orthetrum sabina*	3	6	8
8.			*Pseudothemis jorina*	1	14	-
9.			*Rhyothemis phyllis*	27	16	-
10.			*Tholymis tillarga*	5	-	8
11.		Gomphidae	*Progomphus obscurus*	5	10	-
12.	Zygoptera	Coenagrionidae	*Agriocnemis pygmaea*	9	22	-
13.			*Ischnura aurora*	3	-	-
14.			*Ischnura elegans*	20	11	-
15.			*Ischnura senegalensis*	10	10	-
Total Number of Individuals				**398**	**388**	**321**

Table 3 Habitat types of recorded odonates species from Kandawgyi Lake environs

Sr. no.	Suborder	Family	Species	Habitat types		
				Grasslands	Wetlands	Shrub lands
1.	Anisoptera	Libellulidae	*Acisoma panorpoides*	9	8	-
2.			*Brachythemis contaminata*	74	89	72
3.			*Crocothemis erythraea*	104	43	80
4.			*Diplacodes trivialis*	18	10	34
5.			*Libellula saturata*	65	83	52
6.			*Orthetrum pruinosum*	85	77	52
7.			*Pseudothemis jorina*	-	29	-
8.		Gomphidae	*Progomphus obscurus*	6	10	3
9.	Zygoptera	Coenagrionidae	*Agriocnemis pygmaea*	5	8	5
10.			*Ceriagrion coromandelianum*	6	1	-
11.			*Enallagma antennatum*	11	22	-
12.			*Ischnura aurora*	3	-	2
Total Number of Individuals				**386**	**380**	**300**

Relative abundance and abundance categories of the recorded odonates found in Inya Lake and Kandawgyi Lake environs

During the survey period, a total of 15 species were recorded in Inya Lake environs. Among them, 5 species were abundant, 7 species were rare and 3 species were uncommon. From another point of view, 33 % of the species was abundant, 47 % was rare and 20 % was uncommon in Inya Lake environs (Table 4). Among the recorded species of Kandawgyi Lake environs, 4 species were abundant, 3 were rare, 4 were uncommon and 1 was frequent. *Diplacodes trivialis* was the only species as frequent. In total, 34 % of the species was abundant, 25% was rare, 33 % was uncommon and 8 % was frequent in Kandawgyi Lake environs (Table 5).

Table 4 Relative abundance and abundance categories of recorded odonates species from Inya Lake environs

Sr. no.	Suborder	Family	Species	Individuals	RA	Abundance categories
1.	Anisoptera	Libellulidae	*Brachythemis contaminata*	208	18.79	Abundant
2.			*Crocothemis erythraea*	232	20.96	Abundant
3.			*Diplacodes trivialis*	117	10.57	Abundant
4.			*Libellula saturata*	148	13.37	Abundantm
5.			*Neurothemis tullia*	12	1.08	Rare
6.			*Orthetrum pruinosum*	202	18.25	Abundant
7.			*Orthetrum sabina*	17	1.54	Rare
8.			*Pseudothemis jorina*	15	1.36	Rare
9.			*Rhyothemis phyllis*	43	3.88	Uncommon
10.			*Tholymis tillarga*	13	1.17	Rare
11.		Gomphidae	*Progomphus obscurus*	15	1.36	Rare
12.	Zygoptera	Coenagrionidae	*Agriocnemis pygmaea*	31	2.80	Uncommon
13.			*Ischnura aurora*	3	0.27	Rare
14.			*Ischnura elegans*	31	3.34	Uncommon
15.			*Ischnura senegalensis*	20	1.81	Rare
Total Number of Individuals				**1107**		

Table 5 Relative abundance and abundance categories of recorded odonates species from Kandawgyi Lake environs

Sr. no.	Suborder	Family	Species	Individuals	RA	Relative Abundance
1.	Anisoptera	Libellulidae	*Acisoma panorpoides*	17	1.59	Rare
2.			*Brachythemis contaminata*	235	22.05	Abundant
3.			*Crocothemis erythraea*	227	21.29	Abundant
4.			*Diplacodes trivialis*	62	5.82	Frequent

Sr. no.	Suborder	Family	Species	Individuals	RA	Relative Abundance
5.			*Libellula saturata*	200	18.76	Abundant
6.			*Orthetrum pruinosum*	214	20.08	Abundant
7.			*Pseudothemis jorina*	29	2.72	Uncommon
8.		Gomphidae	*Progomphus obscurus*	19	1.78	Uncommon
9.	Zygoptera	Coenagrionidae	*Agriocnemis pygmaea*	18	1.69	Uncommon
10.			*Ceriagrion coromandelianum*	7	0.66	Rare
11.			*Enallagma antennatum*	33	3.10	Uncommon
12.			*Ischnura aurora*	5	0.47	Rare
Total Number of Individuals				**1066**		

Diversity and evenness of the recorded odonates found in Inya Lake and Kandawgyi Lake environs

The value of Shannon Diversity Index in Inya Lake environs was 2.15548 and Pielou's evenness was 0.795953 and in Kandawgyi Lake environs, 1.93492 and 0.778669 respectively. Both the values of diversity and evenness was greater in Inya Lake environs than Kandawgyi Lake environs (Table 6).

Table 6 Species evenness of Inya Lake and Kandawgyi Lake environs

Study Area	Total number of individuals (N)	Total Number of species (S)	Shannon diversity index (H')	Pielou's Evenness index (J)
Inya Lake environs	1107	15	2.15548	0.795953
Kandawgyi Lake environs	1066	12	1.93492	0.778669

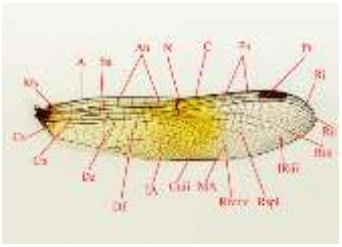
Wing venation of the dominant dragonflies; *Brachythemis contaminata* and *Crocothemis erythraea* from Inya Lake and Kandawgyi Lake environs

Family - Libellulidae
Genus - *Brachythemis* Brauer, 1867
Species - *Brachythemis contaminata* (Fabricius, 1793)

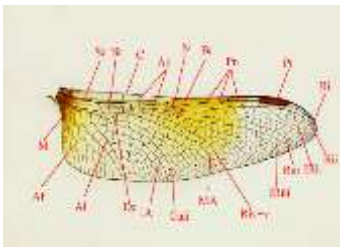
Wings - Hyaline and short, rather rounded at apices; reddish with a broad bright orange fascia extending from base to within 2 to 3 cells of pterostigma in both forewing and hindwing of male. This structure is absent in female. This is variable in extent and depth of color is according to the age.
Reticulation - Closed.
Pterostigma - Moderately large; rust- red in male with posterior border brown and bright ochreous between dark nervures in females.

Discoidal cell - Only the costal side is narrow in forewing and about half the length of basal or distal are traversed; hindwing is entire with base at arc.
Discoidal field - Beginning with 3 rows of cells, its border parallel to wing border.
Arc - Situated between the first and second antenodal nervures.
Sectors of arc - Very shortly fused at origin.
Cubital nervures - Only one in both wings.
Second cubitus - Rising from or separated from the posterior angle of discoidal cell in hindwing.
Anal loop - Rather broadly dilated distally and with distal side strongly angulated.
Anal Field - Developed and many cell rows.
Nodal index - $\frac{8-7\frac{1}{2}}{7-5}\left|\frac{7\frac{1}{2}-8}{5-7}\right.$
Sex - Male
Size - Forewing : 23 mm
Hindwing : 22 mm

The venation is similar in both sexes (Fig. 4). The SEM images of unique structure of the wings; pterostigma, node, vein, cells and the spike on the vein (Plate 3).

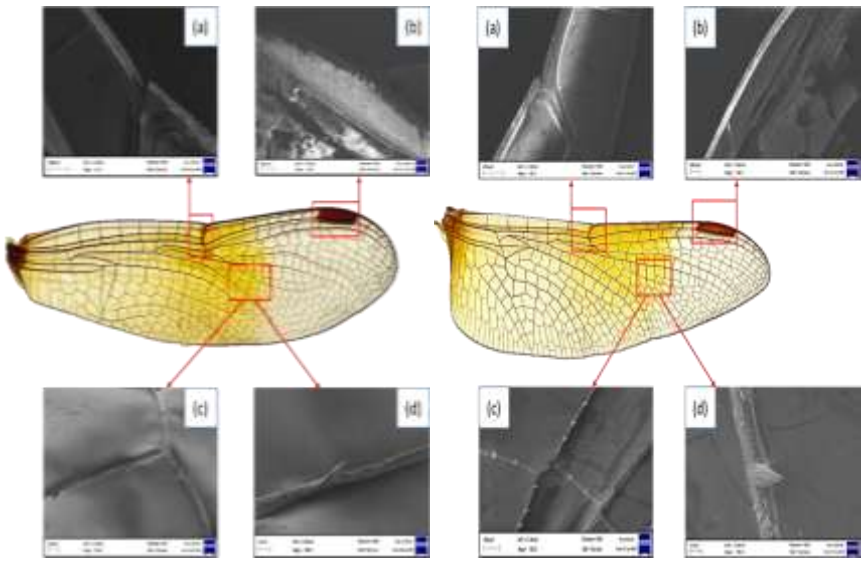


(A)



(B)

Figure.4. The wing venation of *Brachythemis contaminata*'s (A) Forewing (B) Hindwing



(A) (B)

Plate 3 SEM images of unique structure of wing (a) node, (b) pterostigma, (c) vein and cells, (d) spike on the vein of *Brachythemis contaminata's* (A) Forewing (B) Hindwing

Family - Libellulidae
Genus - *Crocothemis* Brauer, 1867
Species - *Crocothemis erythraea* (Brulle, 1832)

Wing - Long and narrow, pointed at apices; hyaline or partly colored at extremely base, the basal amber-tinted marking slightly more extensive. This basal marking is bright orange in male and bright yellow in female.

Reticulation - Closed.

Pterostigma - Large; dark ochreous between blackish nervures.

Discoidal cell - The costal side is straight and narrow in forewing and only half the length of distal and basal sides are traversed; hindwing is usually entirely at the base level of arc.

Discoidal field - Beginning with 3 rows of cells, widely divergent at wing border.

Arc - Situated between the first and second antenodal nerves.

Sectors of arc - Very shortly fused at origin.

Cubital nervures - Only one in both wings;

Second cubitus - Usually arising from the posterior angle of hindwing's discoidal cell.

Anal loop - Widely dilated at distal end and the distal side right-angled.

Anal field - Developed and numerous cell rows.

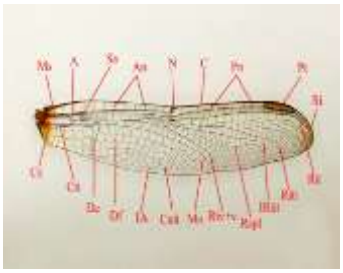
Nodal index - $\frac{10-10\frac{1}{2}}{10-9} \mid \frac{10\frac{1}{2}-10}{10-9}$

Sex - Female

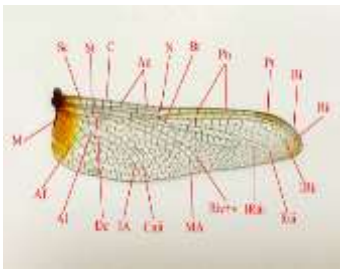
Size - Forewing : 30 mm

Hindwing : 27 mm

The venation is similar in both sexes (Fig. 5). The unique structure of the wings; pterostigma, node, vein, cells and spike on the vein under SEM were described (Plate 4).

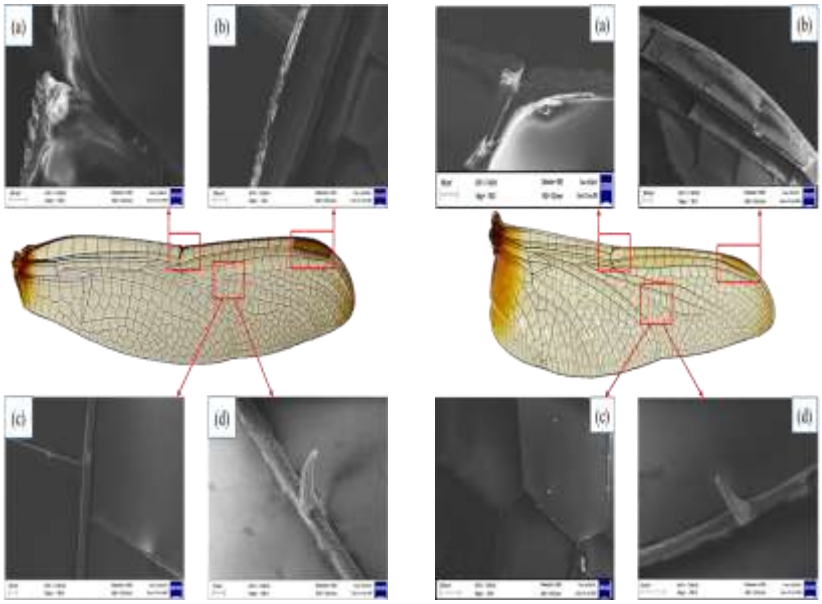


(A)



(B)

Figure. 5. The wing venation of *Crocothemis erythraea*'s (A) Forewing (B) Hindwing



(A) (B)

Plate 4 SEM images of unique structure of wing (a) node, (b) pterostigma, (c) vein and cells, (d) spike on the vein of *Crocothemis erythraea's* (A) Forewing (B) Hindwing

Discussion and Conclusion

A total of 1107 individuals of 15 species belonging to 12 genera under 3 families and 2 suborders of odonates (1022 dragonflies and 85 damselflies) were recorded in Inya Lake environs and 1066 individuals of 12 species belonging to 12 genera under 3 families and 2 suborders including 1003 dragonflies and 63 damselflies) were recorded in Kandawgyi Lake environs during the study period. It is presumed that the environmental impact of Inya and Kandawgyi Lake provide for a large variety of dragonflies but not for most damselflies. Inya Lake environs had more genera and species than Kandawgyi Lake environs. This may be due to the fact that Inya Lake environs have more suitable food sources, habitats and fewer predators for odonates.

From the total recorded species, most of the species were in the family Libellulidae as a dominant family with 61% in both study sites. From Inya Lake environs, the major component of odonates were in the family Libellulidae with 67% and from Kandawgyi Lake environs with 59%. This finding is agreed with Khin Hnin Soe (2011) who found the species community in Thanlyin and Kyauktan environs, Kathy Khine (2013) who studied the species occurrence in Inya and Kandawgyi Lake environs and May Myat Thu (2013) who recorded dragonfly species in Kandawgyi Lake environs. That's why the family Libellulidae may be assumed to be the dominant family in many places of Yangon Region. Only 9 species (7 anisopterans and 2 zygopterans species) were found in both Inya and Kandawgyi Lake environs throughout the study period. It is assumed that these species may be adapted to a wide range of environmental conditions.

Among the recorded species, *Crocothemis erythraea* under the family Libellulidae and *Brachythemis contaminata* also under the family Libellulidae were the most abundant species in Inya Lake and Kandawgyi Lake environs respectively. *Ischnura aurora* under family Coenagrionidae was the least abundant species in both Inya and Kandawgyi Lake environs in the present study. According to Kathy Khine's finding, the most abundant species is *Brachythemis contaminata* in Inya and Kandawgyi Lake environs.

The highest number of individuals were recorded from grasslands in both Inya and Kandawgyi Lake environs. The maximum number of species and individuals were recorded also in grasslands in Inya Lake environs. From Kandawgyi Lake environs, the maximum number of species were observed in grasslands and wetlands. Khin Hnin Soe (2011) and Kathy Khine (2013) pointed out that a greater number of species occupied in wetlands than other habitats. This finding of Khin Hnin Soe (2011) and Kathy Khine (2013) showed slight differences which suggests that habitat conditions may directly influence the presence of odonate species. May Myat Thu (2013) observed that the highest number of individuals were recorded in grasslands. This observation aligns with the present study. This may be assumed that odonates were found in wetlands and grasslands because larvae can only survive in water and it is also their birth place. Grassland may serve as feeding ground for the adult odonates.

Among 5 categories of relative abundance, only 3 categories (47% of the species were rare, 20% were uncommon and 33% were abundant) in Inya Lake environs. In Kandawgyi Lake environs, there are 4 relative abundance categories (25% were rare, 34% were abundant, 33% were uncommon and 8% were frequent). In the present study, Shannon-Wiener index (H') was

2.15548 for the Inya Lake environs and 1.93492 for the Kandawgyi Lake environs. Since the higher the 'H', the value indicates greater diversity, this suggests that the species diversity in the Inya Lake environs is greater than that of Kandawgyi Lake environs. The value of Pielou's evenness index (J) is between 0 and 1. When the value is getting closer to 1, it means that the individuals were distributed equally. The evenness index (J) in Inya and Kandawgyi Lake environs was 0.79593 and 0.778669 respectively. These values indicate a fairly high degree of species evenness in both areas, with some species potentially dominating. However, the overall distribution of individuals among species remains relatively balanced. If a more comprehensive study covering the seasons could be conducted, more diverse odonate species could be observed. The study expends the understanding of odonate biodiversity in Inya and Kandawgyi Lake regions, offering valuable information that can aid in future ecological and conservation efforts.

Both *Brachythemis contaminata* and *Crocothemis erythraea* belong to the family Libellulidae. Species within this family Libellulidae can be distinguished based on the coloration, wings shape, wings markings and the number of antenodal and postnodal nervures present on their wings. The pterostigma also serves as one distinctive feature when identifying the species. The color of the pterostigma in *Brachythemis contaminata* is rust-red with posterior border brown or bright ocherous between dark nervures but it is dark ochreous between blackish nervures in *Crocothemis erythraea*. The cells or membrane of the wings are hyaline in some species and some are partly colored. On the wings of *Brachythemis contaminata*, there is a bright orange fascia extending from base to within 2 to 3 cells of pterostigma in both fore and hindwing but in *Crocothemis erythraea*, the basal amber-tinted marking is present only at the extremely base.

Khaing Sabai (2000) studied 16 species of wing venation but these two species were not included. The position of the node or nodus varies between taxa. According to Needham (1903), the pterostigma, the pigmented spot is developed upon the costa of the wing at the point of greatest impact against the air (Sun and Bhushan, 2012). The unique structure like pterostigma, node, vein, cells and spike on the vein were also studied under Scanning Electron Microscope (SEM) with different magnifications in the present study. Knowing the wing venation patterns can also help in conservation efforts by enabling accurate identification of rare or endangered species. This analysis revealed various types of venation patterns and structural features that are critical for species classification and identification. These findings not only contribute to the field of odontology but also provide essential data for biodiversity conservation and species identification.

Acknowledgments

We would like to extend our heartfelt thanks to Rector Dr. Tin Maung Tun, Pro-rector Dr. Khin Chit Chit, Pro-rector Dr. Cho Cho and Pro-rector Dr. Thidar Aye from the University of Yangon. Our sincere appreciation also goes to Dr. Kay Lwin Tun, Professor and Head, for permission to conduct this research, as well as to the Myanmar Academy of Arts and Sciences for their support in writing this paper.

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