Impacts of Climate Change to the Growth and Development of The Dragonflies of Tram Chim National Park, Tam Nong – Dong Thap, Vietnam

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Abstract. Dragonflies are insects that have an association with wetland ecosystems and sensitive to changes in environmental factors. Therefore, under the increasingly strong impacts of climate change, they exhibit quite pronounced responses. Assessing the growth and development process of dragonflies can contribute positively to assessing and making strategies to cope with the impacts of climate change which is becoming increasingly complicated. The results of the current study showed that the Dragonfly species composition in Tram Chim National Park was remarkably diverse, including 11 species (2008) and 12 species (2019) of larvae belonging to 6 families in 2 subsets Zygoptera and Anisoptera. Based on information from field surveys, the results showed that the presence of dragonflies tended to be earlier than those recorded in the past, and it was often difficult to find them along the survey route, especially nearer to noon. Range, flight speed, and altitude were somewhat reduced, especially for Zygoptera. These environmental factors fluctuated greatly, which might cause pressing impacts on the growth and development of Dragonflies in the Tram Chim National Park area.

1. Introduction

In the context of increasingly complex climate change which impacts on many fields in nature from land, water, to life; the assessment of climate change impacts needs to be carried out punctually to avoid serious damage. Approach from the perspective of recording and analyzing indicator information from the natural world is considered as one of the effective and timely methods of evaluation. The organism is the object directly affected by the impact of climate change, of which the most visible case is the weather-sensitive species.

Dragonflies are a group of insects that are quite sensitive to changes in environmental factors, especially weather factors. Elements of the environment changes will affect the receptors on the dragonflies' body, which leads to physiological reactions, thereby changing their behaviour and ecological distribution in nature. The most noticeable changes are in species composition, the number of individuals, reproductive time, growth, and development. Odonata can be especially vulnerable to the effects of temperatures would reduce survival and increase growth rate when temperature is higher. Because all most stages of Odonata responses to thermal conditions, the higher resource Reduced adult body size and dispersal ability, potentially limiting the ability of Odonata [13][14]. The effects of the current thermal environment with temperatures +2.5° and +5°C above ambient, the condition which
scenario for 50 and 100 years in the future will stock dragonfly larvae. The increasing temperature effects on the timing of the life history transition to the adult stage and size of their wings in adult stage [15].

The impact of climate change effects long-term and very slowly, so the assessment of the expression of climate change through rainfall temperature factors is difficult to recognize in the inland area. However, climate change has a significant impact on groups of organisms that are less likely to move or live only in ecological habitats. Climate change directly affects and significantly changes the growth and development of species. Therefore, to have a complete and accurate assessment of the manifestations of climate change, it is necessary first to start to assess changes in the growth and development of Dragonfly in the present of climate change impacts. Hence, it can institute a foundation for assessing the impacts of climate change on Tram Chim National Park.

Tram Chim National Park have 7,588 ha of wetland in the protected area and a buffer zone of about 20,000 ha, the park and its surrounding areas have valuable wetland resources. There are more than 200 species of birds (16 of which are endangered), turtles, snakes, and fish. Temperature factor in Tram Chim National Park would increase by 0.7°C in the period from 2016 to 2035, by 1.4°C from 2046 to 2065 and by 1.8°C from 2080 to 2099, according to RCP 4.5 scenario. Besides, rainfall distributed unevenly between the beginning and the end of the season, and the hydrological regime was disturbed [3].

2. Study area and methodology

2.1. Study area
Tram Chim National Park is in Dong Thap Muoi, Tam Nong district, Dong Thap province, in the Mekong Delta with an area of 7313 ha.
Geographical coordinates of research area:
- From 10°40’ – 10°47’ north latitude.
- From 105°26’ – 105°36’ east longitude.

2.2. Research Methods

2.2.1. Methods of data collection. Collect secondary data about:
- The ecological situation, natural and environmental factors in Tram Chim National Park.
- Status of forest in Tram Chim National Park.
- Maintenance water level and plan to maintain the water level in Tram Chim National Park.
The survey, verify and quickly assess forest ecological status [3]:
- For slow flowing water areas (V<=0.5 m.s-1), a D net (figure 1) was placed deeply into the bottom about 3-5 cm, drawn a straight line of 50 cm, then pulled up the net. For flowing water area, a 40cm Surber mesh (figure 1) was placed close to the bottom along the flow, then disturb the bottom of the mesh (5cm depth). Water currents swept away the organisms and were retained by the mesh (mesh size 300 µm).
- Time for conducting the survey: 7/2019.

2.2.2. Methods of data analysis. Inheriting the data of environmental factors from the study:
- Research on dragonfly system (Odonata) in Tram Chim National Park, Tam Nong District, Dong Thap Province, by Dang Quoc Quan, 2008.
- With the available data, comparing and making comments on the diversity of the composition of Dragonfly larvae.
STAGRAPHIC XVIII tools were used to synthesize, analyze, calculate data and graph.
Figure 1. D net (A) and Surber mesh (B) to collect the sample.

3. Results and discussion

3.1. Dragonflies in Tram Chim National Park

3.1.1. Development condition. Dragonfly belongs to the insect (Insecta) class, and the lattice wings (Odonata). Dragonflies are currently classified into 3 suborders, including Zygoptera, Anisozygoptera, and Anisoptera. They are classified into 8 clans, 29 families, 58 subfamilies with 600 genera, and 6000 species that have been identified worldwide.

Dragonflies are incomplete metamorphosis insects whose life span goes through four stages: eggs, larvae, molt, and adult. The development time depends on many factors, such as temperature, humidity, food, and habitat. Therefore, the development time of each section may last short or long differently. Dragonflies often lay their eggs in the water or on branches, aquatic leaves near ponds, lakes, and wet areas or in plant tissue in water. Adult ones often live near swamps or ponds. Thereby, it can be seen that the water temperature element is one of the factors that have strongly impacted the growth and development of the Dragonflies. In warm conditions, the larval stage only takes about a month. If the water temperature is low or cold, it will last longer, they can keep this morphology for years.

3.1.2. Dragonfly components at Tram Chim National Park. Dragonfly species composition in Tram Chim National Park included 11 species of larvae (2008) [5] and 12 species of larvae Dragonflies belong to 6 families in 2 sub-sets Zyroptera and Anisotera. Larvae in dragonflies (Odonata) in Tram Chim National Park is generally relatively diversified, the ratio of the larger species, but not the high. Over the years there has been a change in species composition. In the 2019 survey, 1 species of Zygoptera and 2 species of Anisoptera were found (table 1).

Table 1. Dragonfly species composition in Tram Chim National Park (Larvae)

| Specie                     | Family           | Suborder   | 2008 [5] | 2019 |
|----------------------------|------------------|------------|----------|------|
| Ceriagion auranticum (Fraser, 1922) | Coenagrionidae   | Zygoptera  | X        |      |
| Ceriagion indochinense (Asahina, 1967) | Coenagrionidae   | Zygoptera  | XX       | XX   |
| Ischnura senegalensis (Rambur, 1842) | Coenagrionidae   | Zygoptera  | X        | X    |
| Matrona sp.                | Calopterigidae   | Zygoptera  | X        |      |
| Chlorogomphus sp.          | Cordulegastridae | Anisoptera | XX       |      |
| Anax guttatus (Burmeister, 1839) | Aeshnidae        | Anisoptera | X        |      |
The result showed that the number of species in larva increased and increased in the number of families like the values of increasing diversity and the number of species in the areas affected by climate change. Although the number of species increased in 2019, Zygoptera still declined in the number of species as well as quality of species. The result dedicated that the number of individuals of Zygoptera decreased than those in Anisoptera. It might be caused that Zygoptera individuals have small bodies, smaller in-flight range and distribution, less adaptability in the environment which has great temperature changes (table 2).

Table 2. Species composition ratio in the Zygoptera and Anisoptera suborders [5].

| Family               | 2008 | 2019  | Suborder |
|----------------------|------|-------|----------|
|                      | Number of species | Ratio (%) | Number of species | Ratio (%) |
| Coenagrionidae       | 3    | 27,3  | 2        | 16,7       | Zygoptera |
| Calopterigidae       | 0    | 0     | 1        | 8,3        | Zygoptera |
| Cordulegasteridae    | 0    | 0     | 1        | 8,3        | Anisoptera |
| Aeshnidae            | 1    | 9,1   | 0        | 0,0        | Anisoptera |
| Gomphidae            | 1    | 9,1   | 2        | 16,7       | Anisoptera |
| Libellulidae         | 6    | 54,5  | 6        | 50,0       | Anisoptera |

According to the survey results, dragonfly larvae are distributed in all areas, in all seasons. In the rainy season, the number of larvae appears more, mostly concentrated in Melaleuca forests and canals (table 3).

There was no difference in species numbers between habitats during the dry season, but at the time of season and wet season, the current number of grassland species is higher than in other habitats, so it
can be seen from that Grass is an important habitat for larvae to grow and develop, especially at the time of season, rainy season, when there is a plentiful source of food.

Table 3. The distribution of larvae dragonflies (Odonata) at the time of the survey.

| No | Name                  | Surname        | The set         | Appear | Dried         |
|----|-----------------------|----------------|-----------------|--------|---------------|
|    |                       |                |                 | Rain   |               |
| 1  | Matrona sp. (Selys, 1853) | Calopterygidae |                 | Meadow | Melaleuca forests Rice field |
|    | Cercion hieroglyphium (Brauer, 1868) | | | Meadow | Melaleuca forests Rice field |
|    | Cercion plagiosum (Needham, 1930) | Coenagrionidae | Zygoptera | River |
|    | Ischnura senegalensis (Rambur, 1842) | | | River | Meadow Buffer zone |
|    | Sympecma annulata (Selys, 1887) | Lestidae | | Melaleuca forests Buffer zone Canal |
|    | Acisoma pamorpoide (Ranbur, 1842) | | | Meadow | Melaleuca forests |
|    | Crocotelhi servilia (Drury, 1773) | Libellulidae | Anisoptera | Meadow | Meadow Lotus River |
|    | Deiellia phaon (Selys, 1883) | | | Meadow | Meadow Lotus River |
|    | Nannophya pygmea (Rambur, 1842) | | | River | Copper Lotus River |

3.2. The impact of climate change on Dragonfly in Tram Chim National Park

3.2.1. Temperature. During the growth and development period, dragonflies depend heavily on temperature [6][7]. Water temperature significantly affected the hatching time of this group. If the water temperature is warm enough, the eggs will hatch after a few days, but if the temperature is too low, this stage will last longer. At the larval stage, water temperature affects the molting process of the larvae. If the water temperature conditions are appropriate, this will speed up the process occurring in 1 month. But if the temperature is too cold, it will inhibit the ability to develop larvae, they will probably remain in the larval state until the water temperature is appropriate.

The water temperature in Tram Chim National Park ranged from 27.5°C to 29.5°C in the dry season, 26°C to 31.5°C in the in-between season, and about 29°C to 30°C in the rainy season. The rainy season
was the season where most of the Dragonfly larvae appeared, this was an ideal time for Dragonflies in Tram Chim National Park to thrive [5].

According to RCP 4.5 for Vietnam, the annual average temperature in the south could increase from 1.7°C to 1.9°C. Dong Thap province, in particular, could increase by 0.7°C in 2016-2035, an increase by 1.4°C in the period 2046-2065, in the period 2080-2099 increases by 1.8°C [9]. The increase in temperature would lead to a warming of the water temperature, creating extremely favorable conditions, accelerating the growth and development of Dragonfly, thereby dramatically increasing the number of dragonflies, biodiversity at Tram Chim National Park. If the temperature increases by about 2°C, the mortality rate will increase in dragonflies about 10-25%.

During adulthood, dragonflies rely on ambient temperature to begin hunting. Dragonflies usually start hunting at the first light and continue until hunting areas fade into the late afternoon. Hunting becomes less common during cold temperatures, which only happen when there is enough solar radiation. If temperature fluctuations are disturbed, the adult dragonfly's prey will affect their development [11].

During their growth and development, dragonflies are quite dependent on temperature. In the egg stage, most dragonflies of the Odonata order place their eggs in plant tissues, which will hatch after a few days to become true larvae. However, this period depends quite a lot on the water temperature. If the water temperature is warm enough, it will bloom after a few days, but if the temperature is too low it prolongs this period [12].

At the larval stage, dragonfly larvae molt about 9 to 14 times to progress to the larval stage. If the water temperature is right, this will accelerate this process, which can take up to a month. But if the temperature is too cold, which inhibits the ability to develop larvae, they will likely remain in larval state until the water temperature is appropriate [12].

Based on studies of the temperature of air and water temperature in Tram Chim National Park show in Table 4 that the average temperature in Tram Chim National Park ranged from 27.5°C to 29.5°C, the water temperature at the time of delivery the season ranges from 26°C to 31.5°C and in the rainy season it is from 29°C to 30°C. The rainy season is the season when the most larvae of dragonflies are present, so it can be said that the temperature range Water from 29°C to 30°C is an ideal space for Dragonflies in Tram Chim National Park to develop.

| Temperature | Tube meadow | Repentance meadow | Lung lotus | Melaleuca forests | New channel | Old channel | Rice field | Fishpond | Disorder buffer |
|-------------|--------------|-------------------|-----------|-------------------|-------------|-------------|------------|----------|-----------------|
| Dry season  | 28.5         | 28.0              | 28.3      | 28.5              | 26.8        | 28.5        | 29.3       | 28.0     | 29.5            |
| Rainy season| 29.3         | 29.0              | 29.0      | 29.3              | 29.5        | 28.8        | 29.3       | 29.0     | 28.8            |

3.2.2. *Hydrological regime.* The hydrological regime is an essential factor, affecting the entire life of the dragonfly from the egg stage to the adult stage [7].

Dragonfly eggs and larvae completely live in water. Dragonfly larvae breathe with gills at the end of the abdomen. Dragonfly larvae lives on aquatic plants where the water level is not too high, making it easy for them to carry out respiration as well as hunting. Therefore, when the water level is too low, the physicochemical indices of the water are changed, which would directly affect the respiratory ability of Dragonfly larvae and affect their growth.

According to the water level data recorded at Tram Chim National Park from 2009 to 2013 [10], there was instability. This fluctuation considerably affects dragonfly growth during both larval and adult stages. One of the causes of disturbance of the hydrological regime in Tram Chim National Park was to store water by flooding in preventing forest fires. Besides, the arrangement of too many hydroelectric dams in the upstream caused severe water shortage in the downstream. Floods disturbed the hydrological regime in the Tram Chim National Park area, which directly affected the growth of Dragonfly - an insect associated with this water body.
3.2.3. Rainfall. The abnormal rainfall also affected the development of Dragonfly in Tram Chim National Park [7]. Rainfall was unevenly distributed, heavy rains at the beginning of the season, and less at the end of the season, also greatly affected the basin. This was also one of the causes that change the environmental properties and affect the habitat of Dragonflies.

The rain was also the reason affecting the growth conditions of dragonflies. When the air pressure was high, the thin wings of dragonflies could not fly high just close to the ground. According to the survey in the 2006 - 2011 period, the rainfall is relatively stable between years. In September 2010, rainfall seemed unusually high but not insignificant. Average rainfall in Dong Thap province from 2010 - 2015 ranged from 1,392 to 2,338 mm. The rainfall is unevenly distributed according to the seasons, the rainy season from May to November, accounting for 90% of the total rainfall, focusing on September - October. However, at the end of July to early August, there is only one Small rainfall is recorded.

The close relationship between dragonfly abundance and rainfall suggests that dragonflies can be severely affected by a prolonged drought or a long rainy period, such as El Nino or La Nina or caused by climate change.

4. Conclusions

The hydrological regime in Tram Chim National Park was a prerequisite affecting the growth of dragonflies in the larva stage, had huge fluctuations due to the pressure from Climate change and the current state of the infrastructure in there, which caused negative impacts on the growth and development of Odonata, species composition as well as the number of individuals of this group. Water temperature was tending to increase considerably affected the growth rate of Dragonflies. The increase in temperature was a favorable factor for the growth and development of the Dragonflies; however, it would negatively impact due to the adaptive limits of the Dragonfly group.

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References

[1] Le A T and Suppakorn C 2009 Climate change in the Mekong River Delta and key concerns on future climate threats. DRAGON Asia Summit, Seam Riep, Cambodia.
[2] Ministry of Natural Resources and Environment 2020 Vietnam National Biodiversity Strategy – to 2020, vision to 2030 Ha Noi, Viet Nam.

[3] Meynell P J, Nguyen H T, Duong V N, Tran T, Van der Schans M, Shulman D and Shepherd G 2012 An integrated fire and water management strategy using the ecosystem approach: Tram Chim National Park, Vietnam Ecosystems and integrated water resources management in South Asia Routledge, London. pp 199-228.

[4] Quan D Q 2008 Diversity of Dragonfly (Odonata - Insecta) at Tram Chim National Park, Tam Nong district, Dong Thap province University of Science HCMC.

[5] Tuan L A 2009 The impact of climate change on ecosystems and rural development in the Mekong Delta Climate Change Research Institute - Can Tho University.

[6] Hassall C and Thompson D J 2008 The impacts of environmental warming on Odonata: a review. Int. J. Odonatol. ISSN: 1388-7890

[7] Raebel E M, Merckx T, Feber R E, Riordan P, Thompson D J, Macdonald D W 2012 Multi-scale effects of farmland management on dragonfly and damselfly assemblages of farmland ponds Agric Ecosyst Environ. 161 pp 80–87.

[8] Michael L M and Joel M B 1997 Foraging behavior of Pachydiplax longipennis (Odonata: Libellulidae) J Insect Behav. ISSN: 0892 – 7553.

[9] Ministry of Natural Resources and Environment 2016 Scenario of Climate Change and Sea Level Rise for Vietnam Ha Noi, Viet Nam.

[10] Duong V N and Le A T 2015 Review existing water management strategy in Tram Chim National park and develop the new strategy that climate change issues are incorporate WWF – Vietnam, Project No. VN202500 – VZ2100 and VZ4100.

[11] May M and Baird J M 1997 Foraging behavior of Pachydiplax longipennis (Odonata: Libellulidae). Journal of Insect Behavior.

[12] Pilon J and Masseau M 1984 The effect of temperature on egg development in Zygoptera: A preliminary discussion. Brazil. Universite de Montreal.

[13] McCauley S J, Hammond J I, Frances D N and Mabry K E 2015 Effects of experimental warming on survival, phenology and morphology of an aquatic insect (Odonata) Ecol Entomol 40 (3) pp 211-220

[14] McCauley S J and Mabry K E 2011 Climate change, body size, and phenotype dependent dispersal. Trends Ecol. Evol. 26 (11) pp 554–555.

[15] McCauley S J, Hammond J I and Mabry K E 2018 Simulated climate change increases larval mortality, alters phenology, and affects flight morphology of a dragonfly Ecosphere 9 (3)