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POPULATION DYNAMICS OF DAMSELFLY *Agriocnemis femina* (*ODONATA*: *COENAGRIONIDAE*) INHABITED POLLUTED AREA IN PADANG, WEST SUMATRA

DINAMIKA POPULASI CAPUNG-JARUM *Agriocnemis femina* (*ODONATA*: *COENAGRIONIDAE*) PADA KAWASAN TERPOLUSI DI KOTA PADANG, SUMATERA BARAT

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Abstract

Agriocnemis femina known as variable wisp or pinhead wisp, is a damselfly from family *Coenagrionidae* which inhabits various aquatic habitats, including those affected by human. This study aimed to investigate the dynamics of variable wisp in polluted habitat. The tenerals, immature males, adult females and adult males of this damselfly were regularly counted from August 2018 until May 2019 at a 50 m ditch in a clustered settlement in Padang, West Sumatra. It was found that the ratio of teneral, immature male, adult female, and adult male was 1:3:2.4:13.3, implying that the population was dominated by males. Meanwhile, the ratio between female to male (which included the immature males) was 1:6.7. Comparing to the result of counting another population from a relatively clean area, variable wisp showed more dominance in polluted area rather than in clean waterbody. The presence of teneral also indicates that damselfly uses polluted ditch for its breeding site and habitat. The paper discussed the potential causes for damselfly's presence in polluted area, and therefore serves as baseline for future studies.

Keywords: *Agriocnemis femina*; Damselfly; Polymorphic; Teneral

Abstrak

Agriocnemis femina, atau dikenal juga dengan nama capung-jarum centil, termasuk ke dalam keluarga Coenagrionidae yang menghuni beragam habitat perairan, termasuk yang telah mendapatkan pengaruh dari manusia. Penelitian ini bertujuan untuk mengetahui dinamika capung-jarum centil pada habitat yang terpolusi di Kota Padang. Individu teneral, jantan muda, betina dewasa, dan jantan dewasa dari capung-jarum ini dihitung secara rutin dari Agustus 2018 sampai dengan Mei 2019 pada selokan sepanjang 50 m di sebuah kompleks perumahan di Kota Padang, Sumatera Barat. Rasio teneral jantan muda, betina dewasa, dan jantan dewasa yang ditemukan adalah 1:3:2,4:13,3, mengisyarakatkan bahwa individu jantan merupakan bagian yang dominan di dalam populasi capung-jarum ini. Sementara rasio antara betina dan jantan (termasuk jantan muda) adalah 1:6,7. Jika dibandingkan dengan hasil penghitungan jenis serupa yang dilakukan pada kawasan perairan yang lebih bersih, terlihat bahwa capung-jarum centil lebih dominan pada kawasan perairan yang mengalami polusi dibandingkan dengan yang bersih. Keberadaan individu teneral juga mengindikasikan bahwa capung-jarum ini berbiak pada selokan yang terpolusi tersebut, yang mungkin juga menjadi habitatnyat. Hal-hal yang menyebabkan capung-jarum ini dapat hidup pada kawasan yang terpolusi dibahas lebih lanjut di dalam paper ini.

***Kata Kunci**: Agriocnemis femina; Capung jarum; Polimorfik; Teneral*

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INTRODUCTION

About 10% of world *Odonata* species are globally threatened by natural habitat loss, especially those related to the deterioration of natural vegetation and riparian habitats (Kalkman et al., 2007; Miguel et al., 2017; Oliveira-Junior et al., 2015). However, through its wide-distribution and its interaction with environment, some odonate species have developed several physiological and morphological adaptation to cope with the adverse changes (Al-Shami et al., 2014).

Many *Zygopterans* from family *Coenagrionidae* are found in various types of habitats, which serve as predator for other smaller insects. The variable wisp or pinhead wisp (*Agriocnemis femina*) is a species from this family that possess sexual dimorphism as well as polymorphism on its males. They are easily found at various habitats, mostly noted as clean habitats, such as pond, swamp, stream, and river (Pamungkas et al., 2016; Rahadi et al., 2013; Setiyono et al., 2017). Its sex ratio, in relation to the different phases of paddy cultivation, was previously studied at paddy fields in North Sumatra (Siregar et al., 2016). Given that the paddy field habitat is considered as altered, yet less polluted habitat, individuals of *A. femina* were found to be coexisting with many other dragonflies and damselflies. Most ecological studies on *Odonata* conducted in clean area and site, following the nature of this insect group in preferring such type of habitat. As variable wisp was found to exist in urban ditches in Padang, West Sumatra, it is necessary to observe the dynamics of this damselfly in this polluted habitat.

Sex ratio has been one of major topics in studying the evolutionary biology and defined as proportion of male and female progeny produced through reproduction (Wei, 2008). It is influenced by intrinsic and extrinsic factors; the first include genetics, behavior, physiology, while the later include biotic and abiotic aspects in environment such as temperatures, light condition, availability and quality of food and host (Schowalter, 2006; Wrensch, 1993). Sex ratio can vary among populations (Walker, 1984), hence understanding it will give a good idea how a population of insect survive in its habitats. Sex ratio in insect is also important in affecting its mating systems, reproductive strategies, as well as the genetics of insect population (Smith et al., 2005).

This study investigated sex and age-related ratio as well as the population of *A. femina* that inhabited area affected by anthropogenic activities in Padang, West Sumatra. The research aimed to identify the dynamics of variable wisp's life represented by its sex and age ratio in the polluted habitats, such as ditch and sewage in human settlement.

MATERIALS AND METHODS

Study Sites and Sampling Method

The study site was located at a clustered settlement in Parak Kopi Villages, North Padang Sub-District, Padang, West Sumatra. Although most ditches and drainages in this housing complex dwelled by *A. femina* population, the observation was focused only at a 50 x 1 m dirt ditch (hereinafter 'ditch') that used to drain waste water from households in the settlement. The ditch was directly dug onto ground on the side of a small asphalt road within the housing complex. Parts of ditch was mostly shaded by bushes or trees planted in the front yard (Figure 1a & b), irregularly weeded by the respective house owners. It channels sewage disposal from the housing complex into bigger drainage that ends up into Bakali River, one of major rivers in Padang that channels out into Indian Ocean. For comparison purpose, observation data were collected from a spot in Limau Manis campus complex of Universitas Andalas (0° 55' 5.214" S, 100° 27' 9.4572" E, 193 m, not shown in map in Figure 1). This spot is a 30 x 30 m pond (hereinafter 'pond') located near the student dormitory complex of Universitas Andalas. The pond, an open area with slight bushes on its edge, receives regular intake from surrounding brooks, as well as the sewage from the dormitories. According to previous research (Janra, 2018), this is the only location where *A. femina* was observed in Limau Manis campus complex area of Universitas Andalas.

Data Collection

Damselfly *Agriocnemis femina* Count. The individuals of *A. femina* were surveyed on weekly or bi-weekly basis from August 2018 until May 2019, except for January and February 2019

since MNJ, the one who carried out the observation was on leave for a fieldwork expedition. In total, there were 18 observations made at the polluted habitat and seven observations at the clean habitat. The observation was conducted during sunny day, damselfly was visually identified to determine its sex and age, using assistance from relevant guide books whenever necessary (Bárta & Dolný, 2013; Pamungkas et al., 2016; Rahadi et al., 2013; Rembold & Schröter, 2017; Setiyono et al., 2017). Adult males have whitish pruinose thorax with black abdominal tipped with orange tinged, while the immature ones have black and green thorax (Figure 2). Females are usually red in overall, shortly change into this color from their teneral coloration. Despite there might be young females that differ than the adult ones, no such species type was observed during the survey. Hence, there was no category for immature female. The tenerals of both sexes usually resemble the adults or immatures, only with much paler, lighter color, and softer body. Since it was difficult to recognize the sex of teneral just by remote observation without catching and dissecting it, this category was left as just 'tenerals'. The photographical approach was in use in order to facilitate follow up review on counted individuals, as well as avoiding destructing local population (Janra, 2018). Other *Odonata* species as well as other organisms within and around the ditch were also recorded, in order to assess their connection with *A. femina*.

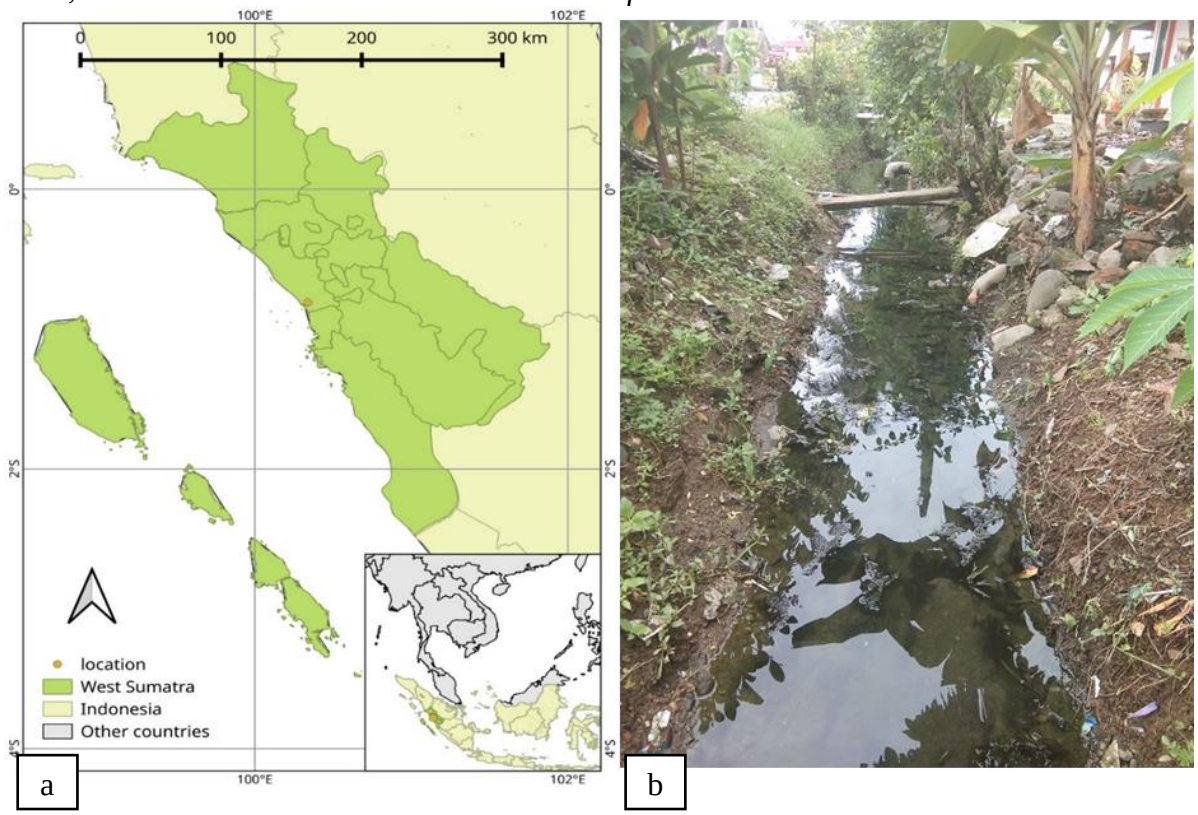

Figure 1. Survey location at a clustered settlement in North Padang Sub-district, West Sumatra, Indonesia (0°55'36.318"S, 100°22'12.349"E) (a) and the ditch where the observation on *Agriocnemis femina* conducted (b)

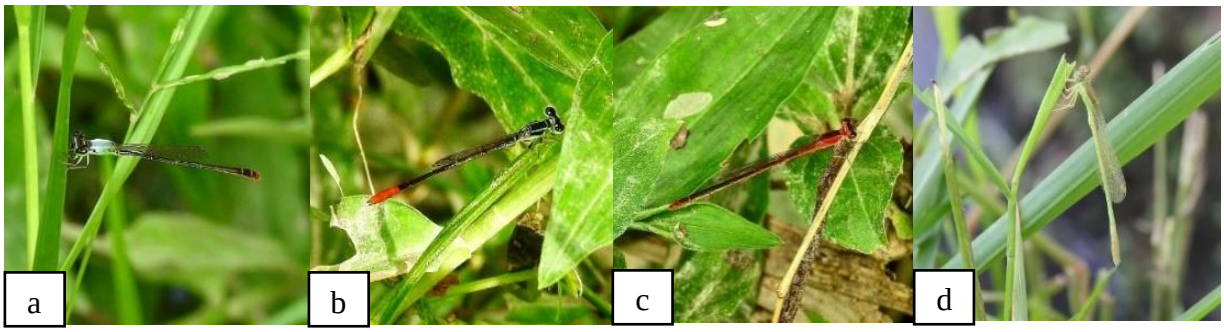

Figure 2. Individual category of *A. femina*: adult male (a), immature male (b), female (c), and teneral (d)

Environmental Factors and Pollution Indicators. Temperature and rainfall were environmental factors used to explain the finding of the study. While the first factor was directly measured during field observation using thermometer, the latter was collected through secondary published sources (Arista et al., 2013; Sudiar & Siregar, 2012). The pollutant level in the sewage was measured by taking waste water samples at upper and lower portion of the ditch on two occasions, namely dry, and rainy season. Meanwhile, water sampling was conducted once at pond area, during a rainy season. The samples were immediately brought to the laboratory in Health Office of Padang to measure the standard indicators for water pollution i.e., biochemical oxygen demand at day 5 (BOD5), chemical oxygen demand (COD), and organic substance (potassium permanganate, $KMnO_4$) according to the established formal standard (The State Ministry of Living Environment, 2003). Other physical pollutants, such as garbage and organic waste, were also recorded.

Data Analysis

In this study, a series of ecological formula provided in Magurran (2004) to analyze the presence of *Agriocnemis femina* at the ditch in the settlement area was applied as follow: $H' = -\sum_{i=1}^{s} pi \ln pi$; C= $\sum(ni/N)^2$; D_i = individual/SU $RD_i = \frac{D_i}{\sum_{i=1}^{j} D_i}$. Where H′= Diversity index, ni= amount of individual for species-*i*, N= amount of all individuals sampled, C= Simpson Domination Index, D_i= density of species, SU= sampling unit, and RD_i= relative density of certain species (Magurran, 2004). This formula was only applied to *Odonate* community in the ditch. The fluctuation of individual in each sex and age category was grouped into a table to find the ratio among categories, which later descriptively detailed with data collected during field observation. The environmental and water pollution data were also in use to support the finding in result.

RESULTS

Age- and Sex-ratio of *Agriocnemis femina*

Population of *A. femina* at ditch mainly consisted of abundant adult males, which gave the highest portion of this category, followed by immature (young) males, females and tenerals (Figure 3). The ratio of teneral, immature male, adult female, and adult male was 1:3:2.4:13.3, while the ratio of adult female to male (immature males included, but tenerals excluded) was 1:6.7. Both age and sex ratio indicate the overwhelming number of males over females or other age classes. Tenerals, on the other hand, provided a feasible reason to believe that this damselfly could breed on site in the ditch, as damselflies do not wander too far from its emergence. Only eleven individuals *A. femina* were counted at pond site; these data, along with other odonates counted result during the survey at both sites are provided in Table 1.

During observation at the ditch, there were three other *Odonata* species recorded from survey area, namely *Orthetrum sabina*, *Diplacodes trivialis*, and *Copera marginipes*; with only several individuals counted (Table 1). It was no surprise that *A. femina* population was much more abundant than other three odonates (RD_i= 90.65%). The diversity of odonata in ditch community was low (H'= 0.39), with indication that *A. femina* population was dominant in the community (C= 0.18). The counting at pond recorded four odonates other than *A. femina*, those were *Ictinogomphus decoratus*, *Orthetrum sabina*, *O. testaceum*, and *O. pruinosum* (Table 1). The *A. femina* population was relatively less than population of *O. sabina* (24.49% versus 28.57%), species that was common in this site. The pond was also more diverse in *Odonata* community (H'= 1.56) compared to what recorded at the ditch.

In addition to other *Odonate* species, at least two *Dipteran* species (mosquitos and fruit flies), two *Amphibian* species, one *Reptile* and a group of reared chicken that occasionally roamed in the ditch for food were also recorded (Table 1).

At both ditch and pond sites, *A. femina* and other *Odonates* were supplied with abundant fruit flies and mosquitoes as their main preys. Occasionally, small *Odonates* (*Zygoptera*) are feasible prey for larger *Odonates* (*Anisoptera*) whenever the latter provided with opportunity to do. *Amphibians* and *Reptiles*, two species represented by some frogs, toad, and skink in this study,

presented similar predation threats to *A. femina* in both sites. However, insectivorous bird species was observed only at the pond site.

Despite the fluctuations of each individual category of *A. femina* observed over time, there were two peaks occurred during population counting, namely on August and November 2018 (Figure 2). The population counting then declined toward May 2019 where no female or immature male was found during the last counting. Population of adult male was always above the populations of other individual categories. During observation, there was no specific segregation among individual categories, as males, females, immature males, and tenerals dispersed across survey sites. All individuals found in each part of the ditch, especially on those shaded and covered by vegetation, while at the pond the *A. femina* tend to perch more on densely bushed areas.

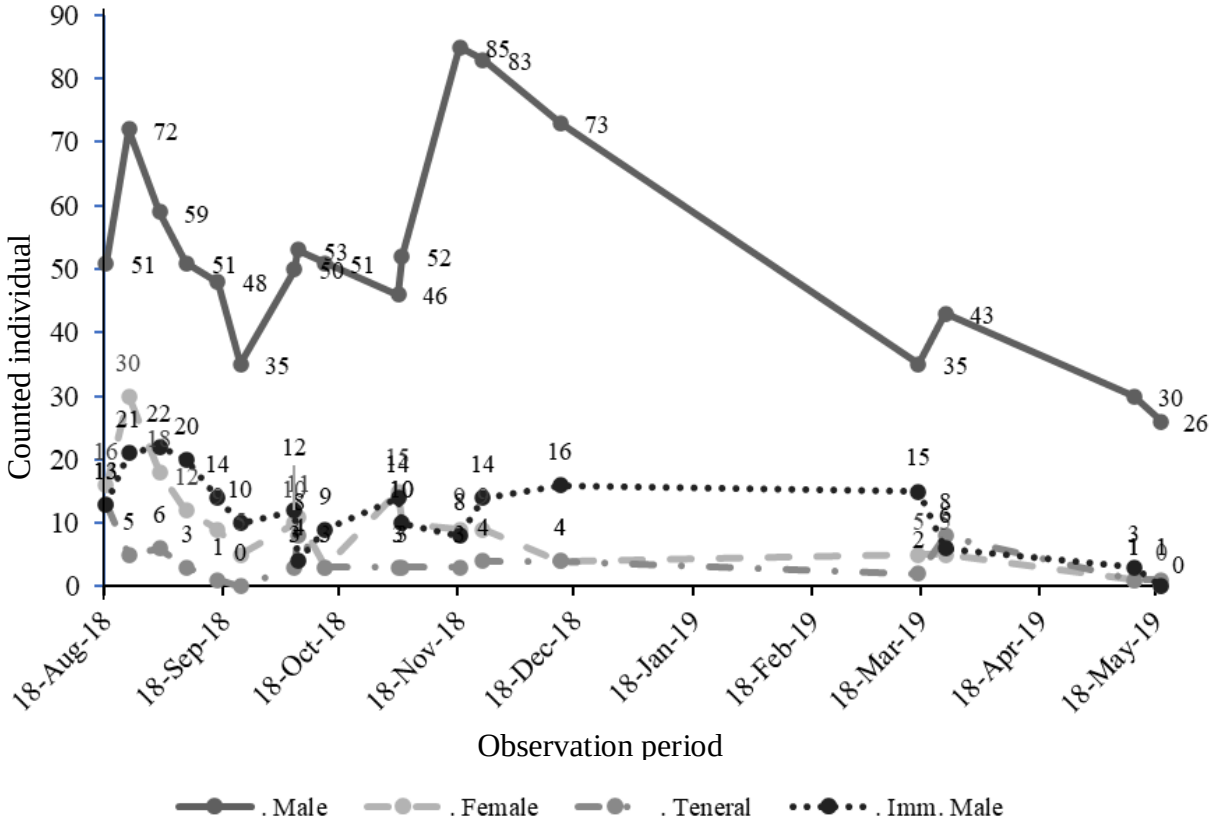

Figure 3. Fluctuation in the number of each individual category of *A. femina* during survey period

Despite the fluctuations in the number of each individual category of *A. femina* that observed through time, there seemed to be two peaks occurred during the counting; on August and November 2018 (Figure 3). The population of all categories then declined toward May 2019 where the least number of females, immature males and tenerals counted. Population of adult male was always above the populations of other individual categories. During observation, there was no specific segregation among individual categories, as males, females, immature males, and tenerals randomly dispersed across survey site. All individuals were found in each part of the ditch, especially in shaded and vegetation-covered area.

Environmental Factors

The ditch was observed to have temperature between 28–38.5 °C, with average temperature of 33.7 ± 2.8 °C (Table 2). The lowest and highest temperature were related to the rainy and sunny days. The highest pouring happened at early November 2019 which culminated into a flash flood and drown the ditch on 2 November 2019.

Table 1. All species observed within ditch and pond area. Individual number for *A. femina* is the average number of individuals counted during survey

Species observed	∑Individual	Di	Rd_i	H_i	C
Odonata					
Ditch (50 m^2)					
Agriocnemis femina	77.6	1.55	90.65%	0.39	0.18
Copera marginipes	1	0.02	1.17%		
Diplacodes trivialis	2	0.04	2.34%		
Orthetrum sabina	5	0.10	5.84%		
Pond area (900 m^2)					
Agriocnemis famina	11	0.012	24.49%	1.56	0.22
Ictinogomphus decoratus	5	0.005	10.20%		
Orthetrum sabina	13	0.014	28.57%		
Orthetrum testaceum	9	0.010	20.41%		
Orthetrum pruinosum	7	0.008	16.33%		
Diptera					
Ditch					
Fruit Flies	Abundant				
Mosquitos	Abundant				
Pond area					
Fruit Flies	Abundant				
Mosquitos	Abundant				
Amphibia					
Ditch					
Duttaphrynus melanostictus	2				
Fejervarya cancrivora	3				
Pond area					
Fejervarya cancrivora	>5				
Odorana hosii	>4				
Reptilia					
Ditch					
Mabouya multifasciata	2				
Pond area					
Mabouya multifasciata	5				
Varanus salvator	1–2				
Aves					
Ditch					
Gallus domesticus	3–5				
Pond area					
Orthotomus ruficeps	2–4				
Prinia familiaris	2–6				
Pycnonotus aurigaster	>3				
Pycnonotus goiavier	>7				

Meanwhile, biochemical oxygen demand on 5 days (BOD5) was different between upper and lower portion of the ditch, where the first ranged between 45.3–79.9 mg/L and the latter was 14.6–17.3 mg/L. At the same time, chemical oxygen demand (COD) ranged between 107–253 mg/L for upper portion and 63.8–133 mg/L at lower portion of the ditch. The maximum quality standard

issued by the State Minister of Environment stated that maximum BOD5 and COD for domestic effluence are 100 mg/L and 30 mg/L, respectively (The State Ministry of Living Environment, 2003). Hence, the waste water that run through the ditch was highly polluted according to this quality standard. Albeit there is no standard for organic substance of potassium permanganate ($KMnO_4$) stated within the ministerial decree, however, the test result indicated that there was organic pollutant in the waste water resulted from household activities. All these indicators were detected at much lower measure at pond, signified the least polluted condition in this site.

Table 2. Measurement on environmental factor and pollution indicators at ditch and pond sites

Sites	Temp. (°C)			BOD5 (mg/L)		COD (mg/L)		$KMnO_4$ (mg/L)	
	Average	Max	Min	Upper	Lower	Upper	Lower	Upper	Lower
Ditch	33.7 ± 2.8	38.5	28	45.3–79.9	14.6–17.3	107–253	63.8-133	17.4–176	4.25–116
Pond	26.5 ± 1.7	29	24.5	3.81		<9.91		9.91	

DISCUSSION

This study presented interesting information regarding the population of damselfly *A. femina*. Its abundance at the polluted ditch indicated its tolerance toward waste water with high organic contaminant; it is in contrary with common paradigm that dragonflies and damselflies are only constrained to clean aquatic body which make them as good environmental indicators (Carle, 1979; Setiyono et al., 2017). The existence of *A. femina* at polluted ditch as observed in this study are thought to be supported by abundant food source i.e., fruit flies and mosquitoes (Schaffner & Anholt, 1998) along with the aquatic or non-aquatic vegetation in the surrounding (Andrés & Rivera, 2001; Wissinger, 1989). Fruit flies, mosquitos, and mosquito larva that live in the ditch provide prey for adults and nymphs *A. femina*. On the other hand, plants around the ditch provide coverage from predators (such as vertebrates recorded in this study) and sunlight, as well as place to deposit eggs especially within the submerged part of the plants.

We assume that the peak of male population on August and November could have connection with mating season for *A. femina* in this site. The abundant males, however, do not necessarily reflect a polyandry system in the reproductive of *A. femina*. This phenomenon is somehow common in damselflies, such as observed in *Ceriagrion tenellum* (Andrés & Rivera, 2001) or in *Ischnura gemina* (Hannon & Hafernik, 2006). The more males available in a given habitat provides the bigger opportunity for females to select the finest mate for reproductive purpose (Silsby, 2001). These observed peaks of male population probably followed slightly behind the climax of rainy season in Padang which usually lasted from September to November (Arista et al., 2013; Sudiar & Siregar, 2012). The rainfall will help reduce the level of aquatic pollution in the ditch and provide more tolerable environment for the development of *Odonate* larvae and nymphs. However, the tenerals were still recorded during a considerably dry period of observation. The overall range of temperature measured in this study was similar to those observed during the study on *A. femina* population at a paddy field in North Sumatra, with temperature never went lower than 28 °C (Siregar et al., 2016).

On the other hand, the tenerals can be considered as sign of reproductive activity commenced in the ditch. The adult *Odonates* (including damselflies) tend to choose habitat where their larvae can have better opportunity to survive, especially in one they spent themselves as larvae (Wolf & Waltz, 1988). In addition, the emergence process that marks the shifting from aquatic life into aerial free-living never takes place in place other than where the nymphs live (Setiyono et al., 2017; Silsby, 2001). The tender body of tenerals requires them to stay waiting in their emergence site until the body is sturdy enough for their maiden flight. This emergence process sometimes takes more than couple days to complete (Rahadi et al., 2013), so it is reasonable to think that the emergence site of *Odonates* should be always at its aquatic habitat.

The lack of predator, especially the bigger *Odonates*, becomes another promoting factor that possibly thrive *A. femina* population at the ditch if compared to that in the clean pond habitat. Previous studies confirmed that the presence of individuals of bigger *Odonata* species triggers some

physiological and morphological adjustments on adults and larvae of the damselflies, hence cost them certain amount of energy (Stoks et al., 1999; 2003; Stoks & McPeek, 2003). It is understandable that the small damselfly species such as *A. femina* will prefer habitats with low number of potential predators, albeit it means living in polluted ones as the trade-off. In our observation site, the ditch seemed not suitable for other *Odonates*, especially the bigger *Anisopterans*, to be used as dwelling place due to their requirement for clean aquatic body for reproduction site. Some individuals observed during our survey, *Orthetrum sabina*, *Diplacodes trivialis*, and *Copera marginipes*, possibly fly in from neighboring habitats after their emergence. Hence, this observation brought idea that this small trade-off can positively favor the existence of *A. femina* in an unclean habitat by optimizing provided advantageous factors.

CONCLUSION AND SUGGESTIONS

In summary, this research resulted in a confirmation that *Agriocnemis femina* inhabited a polluted ditch contaminated by household waste. The proportion of teneral to immature male, female, and adult male or the proportion of female to male was 1:3:2.4:13.3 or 1:6.7 respectively, indicating that male individuals were counted in considerably higher number than other individual categories. The damselfly *A. femina* showed dominance in the polluted ditch, while the number of this species was observed to be oppressed in the clean pond site. The existence of tenerals, furthermore, hinted the possible adaptability of this damselfly to breed within the polluted ditch. The thriving *A. femina* population at this habitat is a possible trade-off by choosing habitat with minimum predators despite the conditions that are far from ideal due to contamination of domestic pollution. In relation to the life of *A. femina* in polluted habitat, many biological aspects of this species are necessarily investigated, such as its aquatic nymphal stage, tolerance level to pollution, also interaction with other coexisting odonates or other organisms that share similar habitat.

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