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SPECIES DIVERSITY OF DRAGONFLY (ARTHROPODA: ODONATA) AND ITS RELATIONSHIP WITH AIR PARAMETERS AT SG. MUAR, KUALA PILAH

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Abstract

The study of diversity and distribution of dragonfly, and their relationship with air parameters (temperature (°C) and humidity (%)) at Sg. Muar, Kuala Pilah, Negeri Sembilan was carried out on 14 and 15 March 2020. The sampling of dragonfly was done in two parts of Sg. Muar, Kuala Pilah. For each site, the sampling was conducted in the morning (8-9 a.m) and evening (6-7 p.m) with the air temperature and humidity were recorded at the same time using the hygrometer and digital thermometer clock humidity temperature HTC-1. Sample collections are carried out by sweeping the samples using sweep net. The samples were collected, preserved and identified until species level. A total of 231 individuals were recorded with *Ischnura elegans* from Coenagrionidae family as a dominant species with 145 individuals (63%), while the lowest abundance is *Pseudagrionidae* sp. of Coenagrionidae family with one individual (0.004%) only. Meanwhile, there is no significant relationship ($p<0.05$) between air parameters with individual number of dragonflies. As a recommendation, other parameters of air and water should be measured to increase our understanding on its effects towards the survivability of dragonfly. This research gives benefit to society and ecology, where it can be used as guidelines for future research, update the checklist of dragonfly and conservation purpose in Sg. Muar, Kuala Pilah.

Keywords: air parameters, diversity, distribution, dragonfly, Sg. Muar

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Introduction

Dragonfly species is one of the insects that belongs to order Odonata (Orr, 2005). Kumar *et al.* (2015) stated that there is a total of 5952 species recognized worldwide in 652 genera of Odonates. Odonates can be divided into two suborders which consist of Zygoptera (damselflies) and Anisoptera (true dragonflies) (Neog and Rajkhowa, 2016). The order Odonata (dragonflies) which comprises of two suborders, Anisoptera and Zygoptera experience an incomplete metamorphosis with larval (naiad) stages experiencing 10 to 15 instars. The larvae usually hide themselves by either tunnelling through the substrates, rambling among fine sediments and garbage, or getting on vascular plants (Ameilia *et al.*, 2006).

Dragonflies species are colourful and large-eyed insects that can show sexual dimorphism, colour transition and colour polymorphism (Futahashi, 2016). Furthermore, they have their own characteristics that can be distinguished from other insects where they can be recognized by their long and slender abdomen, large globe-shaped eyes on their head with short antennae and two pairs of wings (Neog and Rajkhowa, 2016). Their head is large with flexible neck, three ocelli and a pair of short, bristle-like antennae. According to Corbet (2013), adults' dragonfly easily perceived because they have two pairs of narrow, transparent wings, sloping thorax and a body longer than the wings. Besides, they are large insects with striking coloured body where ranging from metallic to dull, occasionally in combination. The young or nymphs however are wingless with a well-camouflaged colour as the sediments or water

around them.

According to Choong *et al.* (2018), nearly 400 species of Odonata from 17 families were found in Malaysia. At least 180 species are dragonflies and 210 species are damselflies. According to Orr (2004), the Odonates fauna in Malaysia consists about 342 species, including 161 Zygopterans (10 families) and 181 Anisopterans (five families). For Sabah, Sarawak and Brunei, there are about 239 species reported while 226 species listed from Peninsular Malaysia and Singapore (Norma-Rashid *et al*., 2001). Some of the native species in Malaysia are *Amphicnemis bebar, Brachythemis contaminate, Sympetrum flaveolum and Ischnura elegans* (Yen *et al.*, 2018) whilst non-native families such as Chorismagrionidae, Dicteriadidae, Hemiphlebiidae and Isostictidae (Tennessen, 2009).

A study by Dow and Reels (2015) showed that dragonflies can be found mostly in tropical rainforests. Tropical forests have the greatest species diversity of dragonflies as they have rich ecosystems (Manwar *et al*., 2012). According to Korkeamäki and Suhonen (2002), most Odonata have their own preferences of their habitat such as riparian vegetation, overhanging vegetation and riparian forest. Regardless the size of the location or habitat, the most abundance of Odonates recorded near water bodies such as ponds, lakes, streams, waterways and canals. Since dragonflies need water to lay their eggs, they are widely distributed in watery ecosystems (Corbet, 1999). The larvae possess an extraordinary decent variety of aquatic surroundings and structure significant segment of aquatic food webs including numerous invertebrates, fishes and different vertebrates (Ameilia *et al.*, 2006).

Neog and Rajkhowa (2016) also stated that dragonflies can act as environmental quality indicator and involve in food web both as preys and predators; as larvae and as imagoes. According to Suhonen *et al.* (2002), the diversity and abundance of dragonfly decrease if the environmental quality drop. According to Sheldon and Walker (1998), Odonata demonstrate their unique habitat preferences through their distribution, which is involved primarily microhabitats. These insects lay their eggs in or near freshwater and thus their high abundance in the area is a clear indicator of the freshwater quality (Acquah *et al.*, 2013).

There is lack information on Odonata species especially in Kuala Pilah, thus this research will be beneficial in providing knowledge on the diversity and distribution of dragonfly at Sg. Muar, Negeri Sembilan. The objectives of the study are to identify the diversity and abundance of dragonflies and to determine their relationship with air parameters such as humidity (%) and temperature (ºC) at Sg. Muar. The present finding will help to increase human awareness on the importance of dragonflies in ecology especially as an indicator of environmental quality and the significant to plan with the conservation process. It can also be used as future guideline for other studies of diversity and distribution of dragonfly in Sg. Muar, Negeri Sembilan.

Methods

Sampling Area

Kuala Pilah is a district in Negeri Sembilan with the area of 109,039.58 hectare (ha). The main basin river in Kuala Pilah is Sg. Muar. The length of this river is about 45 km including water catchment area of 1,090 km^2. Sg. Muar flows across Kuala Pilah, Bahau and Gemenceh in Negeri Sembilan. In this research, two stations were chosen along Sg. Ulu Muar. First station (Station 1) is located at coordinates of N 02°44.893' E 102°14.885' and the second station (Station 2) is located at N 02°45.358' E 102°15.230'. The coordinates were taken using Garmin GPSMAP 62 Series.

The width measurements of each station were taken within 300 meters interval using measuring tape. The width measurements for Station 1 are 10.8 m, 8.5 m and 9.3 m while for Station 2 are 11.22 m, 13.9 m and 13.1 m.

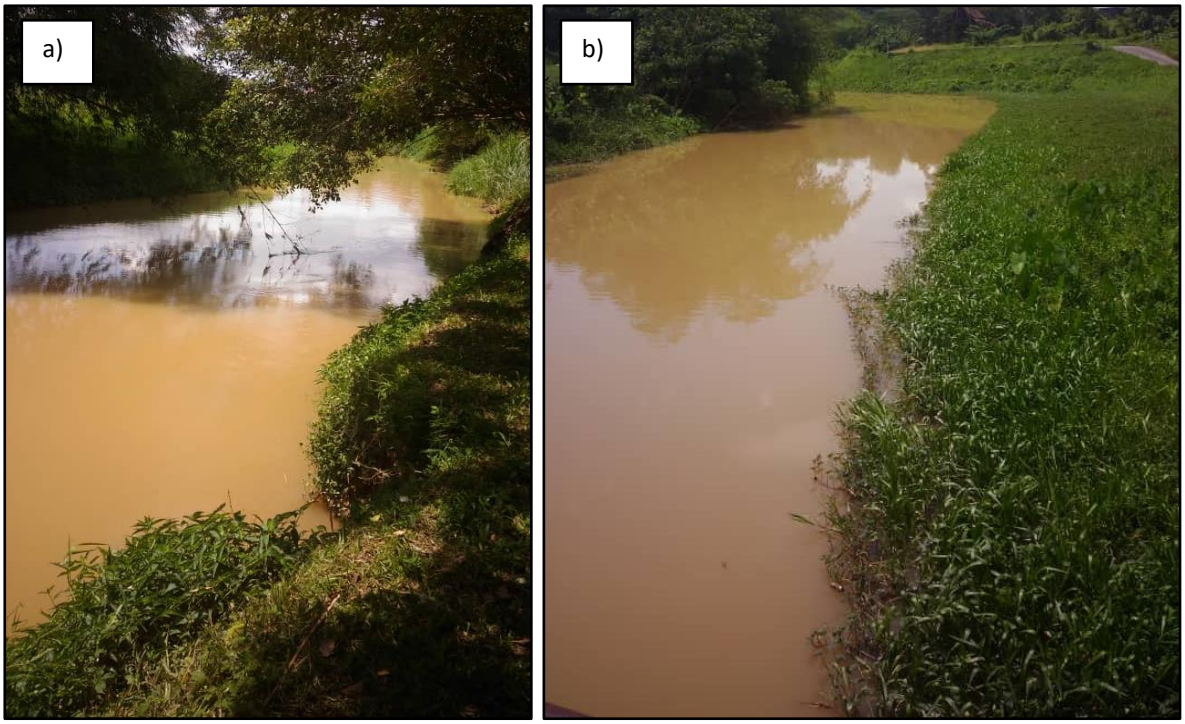

Figure 1. a) Station 1, and b) station 2 of Sg. Muar, Kuala Pilah

Net Sweeping

Sweeping nets were used to capture the samples of dragonflies. Based on Orr and Hämäläinen (2003) and Borror and White (1970), the insect nets were strong and light with a 2 ft (24 in) long handle and about 25 cm diameter of open mesh net with little air resistance. Hence, it is swung rapidly to catch the flying dragonfly (Orr, 2013).

Samples Collection and Drying Preservation

The samples were picked from the net and put in a plastic container containing two units of cotton balls. These cotton balls were dipped in the chloroform solution (formula $CHCl_3$) before placed in each plastic container. The function of chloroform is to ensure the samples were faint and died before pinning their thorax with insect pin. Then, the sample were placed in an envelope with its wings folded together above the body to prevent sample from being damaged (Wahizatul-Afzan *et al*., 2006). Later, the envelopes were labelled with station and time of sampling. The samples were refrigerated at 5°C in the fridge to soften the samples. Then, it was dried in the oven for 24 hours at 45°C. Then, the preserved samples were stored in dry storage box. The mounting process of the dragonfly was done on the mounting board with Styrofoam where the sample were pinned at the thorax with the wings spread 180°. Second sampling activities were conducted by following the similar steps as above. The replication was carried out to avoid bias and ensure that the findings are accurate and reliable in comparison with the first results.

Species Identification

The samples were identified up to the species level and all data obtained were recorded. Samples were identified by referring to "A Guide to the Dragonflies of Borneo" (Orr and Hämäläinen, 2003) and "Dragonflies of Peninsular Malaysia and Singapore" (Orr, 2005). The species of dragonflies that have been identified were recorded.

Determination of Air Parameters

Air humidity (%) and temperature (°C) were measured using hygrometer and digital thermometer clock humidity temperature HTC-1 (no brand). The air parameters were measured three times during every sampling in each station and the data were recorded.

Statistical Analysis

The data were recorded and arranged in Microsoft Word 360 and Microsoft Excel 360. Paleontological Statistics Software Package for Education and Data Analysis (PAST 3.22) (Hammers *et al.*, 2001) was used for diversity index analysis while Minitab 19 was used for two-sample-*t*- test and correlation coefficient analysis.

Result and Discussion

Species composition of Dragonfly (Arthropoda: Odonata) in Sungai Muar, Kuala Pilah

A total of 231 individuals of 11 species representing five families of Odonata had been successfully collected in both stations in Sg. Muar, Kuala Pilah. The families of Odonata identified; Coenagrionidae, Libellulidae, Gomphidae and Platycnemididae were all present in both stations except for Lestidae which was absent in station 1 and only two individuals of *Lestes virens* from this family collected in station 2. The highest distribution species in both stations is *Ischnura elegans* that belong to the Coenagrionidae family with the total of 145 individuals (62.8%). Meanwhile, the lowest distribution species is *Pseudagrionidae* sp. also from the same family with only one individual collected which represents 0.4%.

Table 1 below shows that station 1 has a higher distribution of dragonfly with 120 individuals (51.9%) of eight species (72%) from four different families compared to station 2 with only 48% representing 111 individuals of nine species (82%) from the total (231 individuals; 11 species). The dominant species in station 1 is *I. elegans* with 87 individuals (72.5%), followed by *P. humeralis* with 21 individuals (17.5%), *C. chaoi* with four individuals (3.3%) and *I. senegalensis* with three individuals (2.5%). Lastly, the species that were collected by one individual only including *Pseudagrionidae* sp., *A. bebar* and *G. perakensis*.

Dominant species collected in station 2 is *I. elegans* with 58 individuals (52.3%) from total of 111 individuals, followed by *C. gigantea* (15 individuals; 13.5%), *P. humeralis* (13 individuals, 11.7%), *I. senegalensis* (10 individuals; 9%), *B. confaminata* (five individuals; 4.5%), *A. bebar* with (four individuals; 3.6%), *S. flaveolum* (three individuals; 2.7%), *L. virens* (two individuals; 1.8%) and only one individual (0.01%) of *G. perakinsis*.

Table 1. Composition of dragonfly species (Arthropoda: Odonata) at Sg. Muar, Kuala Pilah

Family	Species	Station 1	Station 2	Total
Coenagrionidae	*Amphicnemis bebar*	1	4	5
	Ceriagrion chaoi	4	0	4
	Ischnura elegans	87	58	145
	Ischnura senegalensis	3	10	13
	Pseudagrionidae sp.	1	0	1
Gomphidae	*Gomphidictimus perakinsis*	1	1	2
Lestidae	*Lestes virens*	0	2	2
	Brachythemis confaminata	2	5	7
Libellulidae	*Camacinia gigantea*	0	15	15
	Sympetrum flaveolum	0	3	3
Platycnemididae	*Prodasineura humeralis*	21	13	34
Total		**120**	**111**	**231**

The samplings were conducted in each station in the morning (8-9 a.m) and evening (6-7 p.m) as in Figure 1. The *I. elegans* can be seen everywhere during the morning sampling than evening sampling at both stations with the total number caught is 124 individuals. They are mostly seen in mating position;

heart shape or wheel shape. While during the evening sampling, only few of them are seen flying and only 10 individuals were caught. According to Hammers *et al.* (2009), usually *I. elegans* is actively in mating state from 08:00 until 16:00, but the mating activity is at peak between 10:00 to 15:00. *Ischnura elegans* is the most individuals caught in the morning at station 1 and station 2. There is also 15 individual *C. gigantea* from Libellulidae recorded during morning sampling at station 2 but no individual recorded in station 1. However, they can be observed flying from stalk to another stalk of plant along the river (Figure 2). According to Clausnitzer (1998), the males of Libellulidae are active in their territories 10:00 and 16:00. About 95% of dragonfly spent their live in territories by perching where males sit on the short vegetation to protect their territories while foraging for food. *Prodasineura humeralis* only recorded in evening sampling at both stations and none observed during morning sample. Previous study by Cai and Ngiam (2018), described that *P. humeralis* can be seen more in the suburbs and fast flowing stream stretches with an open canopy. However, they are difficult to be found in shaded forest streams.

According to Kalkman *et al*. (2007), Coenagrionidae and Libellulidae are the two largest families of Odonata that are convinced to be relatively recent. Species that belong to this family occupied in unshaded water bodies habitats. A research in Southern Brazil by Pires *et al.* (2013), found that Lestidae family represented by one genus and only presence in lentic habitat or Lentic habitat. Hence, Lestidae prefers lentic habitat. Lentic environment characterized by water body that do not flow such as lakes and ponds (Marsh and Fairbridge, 1999). River is the sampling sites of habitat with running water which refers to lotic habitat.

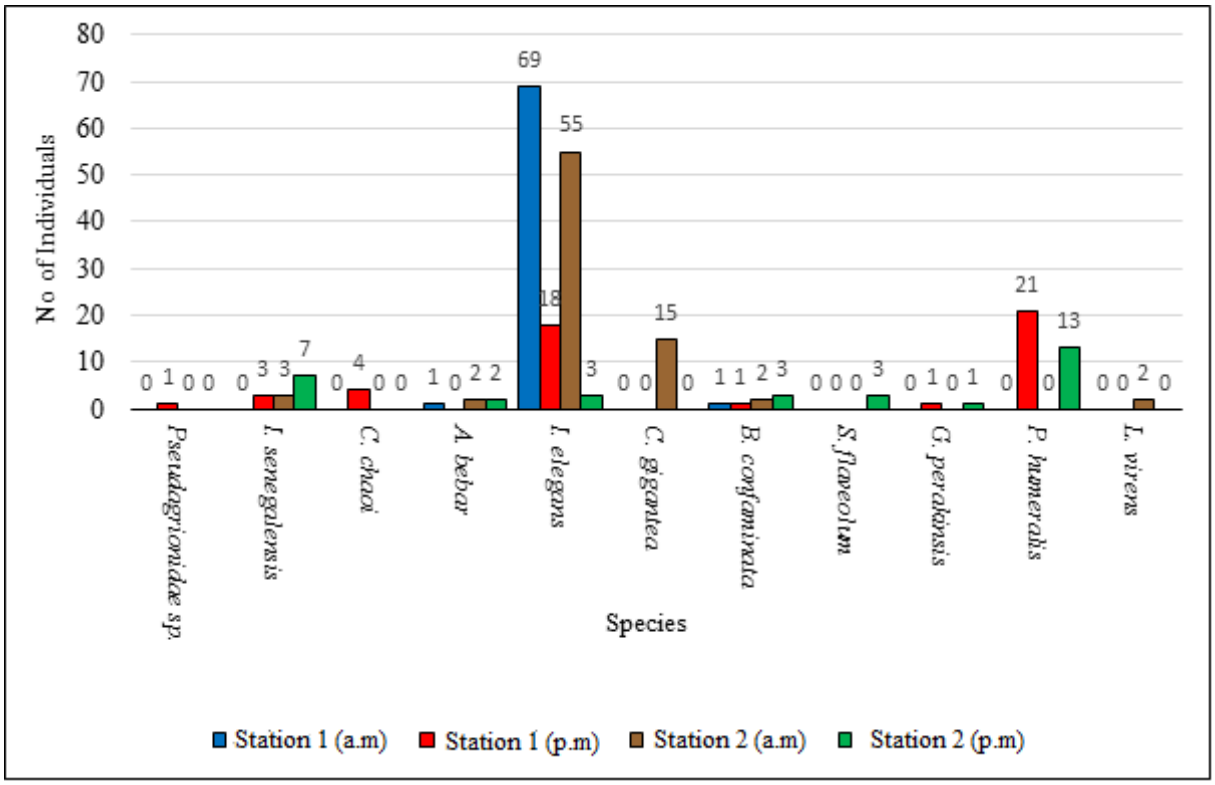

Figure 2. Number of individuals during morning and evening sampling at station 1 and station 2

Currently, due to changing environmental conditions, the composition and distribution of aquatic insects are constantly changing (Ameilia *et al.*, 2006). Brasil *et al.* (2020) stated that the distribution of aquatic organisms is directly influenced by local environmental variables; width of water bodies, vegetation covers and rainfall. Besides, anthropogenic disturbances also affect these organisms as human modified the environmental conditions in ecosystem for example urbanization and industrialization.

The female's dragonfly will choose not to oviposit at the disturbed sites of stream conditions because of the water speed and the lost or change in type of vegetation (Luke *et al.*, 2017). In addition, Luke *et al.* (2017) also stated that eggs and larvae of dragonfly have lower survival rates and sensitive to high temperature. The research of the number of dragonfly larvae between palm streams and oil palm in forest resulted more at oil palm in forest as it is lower in temperature. Being one of the predators of macroinvertebrates, the dragonfly larvae are affected by the diversity of the macroinvertebrates in a habitat which are influenced by the changes in inputs of water, sediment, organic matter and light of the freshwater systems.

Based on observation, station1 and station 2 are disturbed by human activities. At station 1, there is a housing area near the river. All domestic waste from there were dumped through drainage into the river. In addition, there are water dam and road bridge that makes the area affected with sound pollution from the cars. Same goes to station 2 where there is an unidentified large abandoned machine at the river bank that might disturb the water quality there. These anthropogenic activities might affect the diversity and distribution of dragonflies.

Diversity Analysis of Dragonfly

Overall, Table 2 recorded that station 2 has a higher Shannon-Wiener index (H'= 1.549) compared to station 1 (H'= 0.9317). The higher the diversity index, the more the degree of species composition per unit area and greater the diversity at the place (Wahizatul-Afzan *et al.*, 2006). Although the total number of individuals at station 2 is lower than station 1, but there are more species of dragonfly were caught and identified at station 2 with nine species, while station 1 with eight species only. Therefore, the higher number of dragonfly species at station 2 has influenced the analytical value indicated by the diversity index (H'). Based on a study done by Ameilia *et al.* (2006) on the diversity and abundance of dragonfly Odonata, the biological index values shows that the dragonfly fauna in Kerian River Basin is relatively low due to the variation of physical-chemical parameters of water (Ameilia *et al.*, 2006).

Evenness index shows the homogeneity or distribution pattern of species in relation with other species (Wahizatul-Afzan *et al.*, 2006). The species evenness value range from 0 to 1. Value 1 indicates complete evenness, while value 0 indicates no evenness (Kvålseth, 2015). The Evenness index shown at station 2 also is higher than station 1 with E'= 0.5232 and E'= 0.3173, respectively. The number of individuals of each species for station 2 is quite small in gap rather than in station 1 where each numbers of species are not close to each other and have large gap. Based on this analysis, it is proved that the dragonflies' abundance at station 2 is more even than station 1. However, the value of evenness index was recorded at both station is low maybe due to the location of the river is far from forest area and facing to some anthropogenic stress such as road and building construction. Contradict to this study, the evenness index shown by Koneri *et al.* (2017) indicate that the primary forest consists of highest species diversity and evenness while the lowest was in secondary forests.

Station 2 also recorded higher Margalef index (R'= 1.699) compared to station 1 with R'= 1.462. This index shows the abundance of the species per unit area (Wahizatul-Afzan *et al.*, 2006). The number of species caught at station 2 is more abundance than station 1. Two-sample-*t*-test was used to determine the means between two groups whether there is any significance difference. The result shows that there is no significance difference between the abundance of dragonfly in station 1 and station 2 with p=0.931 (p>0.05). From this finding, it can be concluded that the ecosystem of Sg. Muar is stable due to the high index value of all indices. This statement is supported by Javaid and Ashok (2013) which states that high Simpson dominance index value (0.6 to 0.9) indicate that the communities is mature and stable, while low diversity index indicates that the communities under stress conditions which is usually close to zero values. According to Adu *et al.* (2016), Ago Store Pond, located in Ago Store Camp (AGO) have experienced larger anthropogenic pressure by having the Simpson dominance index value of 0.5 which is less than the threshold of 0.6.

Table 2. Diversity index (H'), Evenness index (E') and Richness index (R') between Odonata in Station 1 and Station 2

Index	Station 1	Station 2
Shannon-Wiener (H')	0.932	1.549
Evenness (E')	0.317	0.523
Margalef (R')	1.462	1.699

Correlation Coefficient between Individual No of Dragonfly (Arthropoda: Odonata) with Air Parameters

The correlation between diversity and distribution of dragonfly in station 1 and station 2 with air parameters was determined using correlation coefficient analysis. According to Ganti (2020), the values of correlation coefficient is between -1.0 and 1.0. If the value calculated is -1.0 it refers to a perfect negative correlation, while if it is 1.0, it shows perfect positive correlation. In addition, the value of 0 means that between the two variables, there are no linear relationship. According to Haeck *et al.*, (2012), the value of low correlation is 0.10-0.29, moderate correlation is 0.30-0.49 while high correlation is between 0.50-0.10. Table 3 shows the individuals' relationship in station 1 and station 2 with the air parameters. For station 1, there is positive moderate correlation but not significant between number of individuals with the temperature (r= 0.388; p>0.05), and moderate correlation but not significant between number of individuals with humidity (r= 0.421; p>0.05). The results congruent with Trottier (1973) where the survival and activity of terrestrial arthropods were highly affected by the temperature and humidity.

Table 3. Correlation coefficient between individual number of dragonfly species at Sg. Muar 1 and Sg. Muar 2 with the air parameters

		No of individual	
Station	**Air Parameters**	***p*-value**	**Pearson's correlation, *r***
Station 1	Temperature (°C)	0.239	0.388
	Humidity (%)	0.197	0.421
Station 2	Temperature (°C)	0.151	-0.464
	Humidity (%)	0.903	-0.042

Station 2 shows the same result as in station 1 where the temperature and humidity both is not statistically significant towards the number of individuals as both p>0.05. However, the difference is there is strong negative correlation between number of individuals with temperature (r= -0.464) and low negative correlation between numbers of individuals with humidity (r= -0.042) compared to station 1 with the positive r-value. Based on results, negative in r value shows when humidity and temperature increases, the number of individuals would decrease and vice versa. The temperature measured at station 1 and 2 is in range of 34.8-35°C and 29.6-29.8°C, respectively. While, the humidity of station 1 is in the range of 58-60% and 59-61% for station 2. The slightly changes of temperature and humidity at both stations does not affect the abundance of dragonflies.

The relationship between air parameters and the total number of individuals in both stations was analysed. The result of this test shows that there is no significant correlation between temperature (low; r=0.247, p>0.05) and humidity (medium; r=0.554, p>0.05) with the total individual number of dragonflies. Based on a study done Al-Digail *et al.* (2012) on beetle, the Pearson's Correlation coefficient is highly significant difference ($p<0.01$) between number of eggs and temperature while there is significant difference ($p<0.05$) between humidity and number of beetles.

Conclusion

The samples of dragonfly caught at both stations were successfully identified and the diversity analysis

was completed. The most dominant species caught in both stations is *I. elegans* that belongs to Coenagrionidae family. Based on the data analysis, high value of all Shannon-wiener (H'), Margalef (R') and Evenness (E') indexes prove that the ecosystem of Sg. Muar is mature and stable. Then, there is no significant correlation between temperature and humidity with the total individual number of dragonflies. The environment of Sg. Muar is considered as sustain as it is still suitable for the dragonfly to stay in the habitat. There is a possibility of other parameters such as water parameter can be included and measured in the research to find if there is relationship between Odonata species and water parameter that affected the dragonfly distribution and diversity.

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