# Effect of Light Availability on the Abundance of Grazer Type Aquatic Insects at Kurokawa River, Japan

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## Abstract

A short-term research study was carried out under the DIWPA International Field Biology Course 2012 in Kiso County, Nagano, Japan. The purpose of this study is to investigate the possible relationship between sunlight availability and the abundance of herbivorous aquatic insects (grazers). Field sampling was conducted at Kurokawa River to collect the zoobenthos specimens from exposed stream bed. The specimens were then analysed at Kiso Biological Station of Kyoto University. They were identified and examined according to the light availability (opened or shaded) at different habitat types (riffle or pool). As a result, the zoobenthos communities consisted of five Orders of aquatic insects, pupa and non-insect organism, and they are dominated by two feeding groups: grazer and mix diet insects. The analysis showed that the grazers are more abundant at riffle habitat regardless of light availability. However, the grazers are significantly more abundant in the opened area for riffle habitat, but very little difference between opened and shaded areas for pool habitat. It is concluded that the habitat type is a stronger indicator of the abundance of grazers in this river system. Further investigation to support the statement is suggested.

## 1. Introduction

Theoretically, growth of photosynthetic algae is depending on sunlight availability. The more sunlight access, the better the growth of algae in a common aquatic environment. On the other hand, epilithic algae are important food source to a group of herbivorous aquatic insects. These aquatic insects, which generally termed as “grazer”, belong to the families of Leptophlebiidae, Ephemerellidae, Baetidae, Siphlonuridae and others. With this view, it is reasonable to link the light availability with abundance of grazer type aquatic insects in stream or river habitat. A hypothesis arises to assume that there is connection between sunlight availability and abundance of grazers in the freshwater ecosystem. The relationship was scientifically examined by a short-term study from 20$^{th}$ to 23$^{rd}$ August 2012 under the DIWPA International Field Biology Course in Japan.

## 2. Methodology

### 2.1 Study Site

The study site is Kurokawa River, which located in Kiso District, Nagano Prefecture, Japan (Figure 1). The working area covered approximately 200m along the the Kurokawa River at the point of 35$^{o}$ 52.516’ N, 137$^{o}$ 40.511’ E.

There are basically two types of habitats at this study area, riffle and pool. The riffle habitat is potentially with lower temperature, higher dissolve oxygen (DO) and higher water current compare to the pool habitat.

Numerous zoobenthos could be found within this area, including Insecta, Oligochaeta, Turbellaria, Hirudinea and Hydrachnellae. There are a total of 35 families of aquatic insects being identified from the field survey, which conducted by the researchers of DIWPA International Field Biology Course on 17$^{th}$ - 24$^{th}$ August 2012. The rich biodiversity of zoobenthos generally indicates a healthy freshwater ecosystem within this area of Kurokawa River.

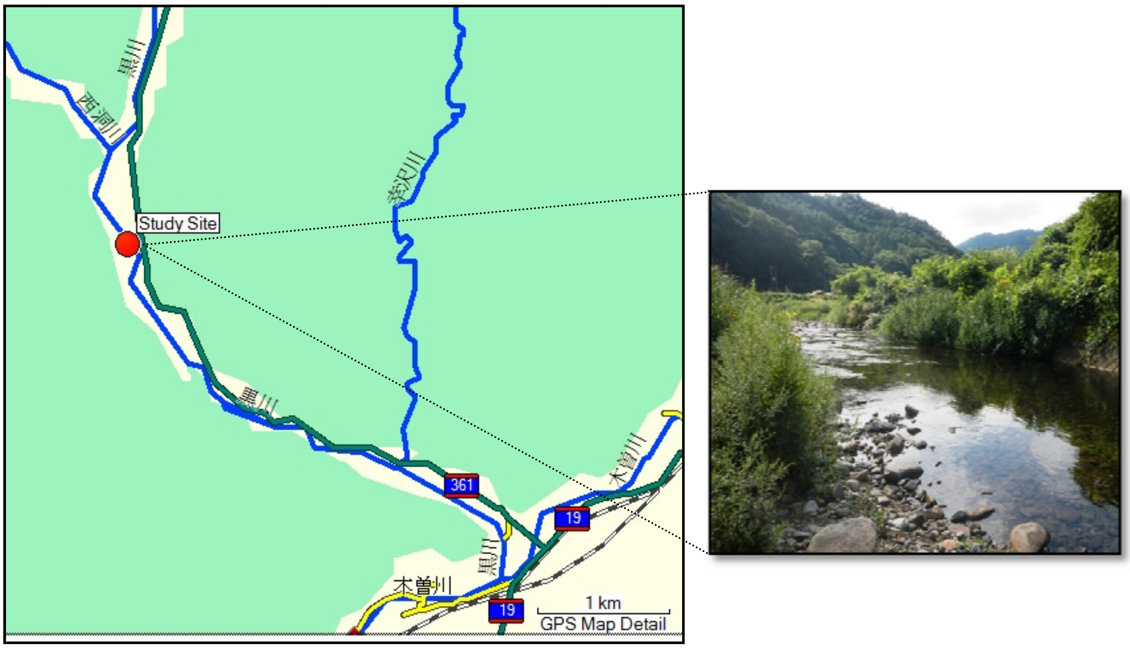



**Figure 1**: Study site at Kurokawa River (marked as red dot in the left side figure) and the surrounding environment of this site (right side figure). Map generated by Kimon Berlin, © OpenStreetMap contributors, CC-BY-SA.

### 2.2 Sampling in the Field

It was a sunny weather for both the field survey and research sampling on 20$^{th}$ and 21$^{st}$ August 2012. From the field survey, four categories of sampling sites were identified with consideration of habitat type and light condition. They were riffle without shade (RO), riffle with shade (RS), pool without shade (PO) and pool with shade (PS).

For field sampling, two 50cm x 50cm quadrates were set up at respective sampling site. Each sampling point (50cm x 50cm quadrate) was taken photo to show the environmental condition and possibly the abundance of epilithic algae on rock surface. Then, at each quadrate, three rocks measuring 10 - 20cm in length and 5 - 10cm in thickness were randomly collected from the exposed layer of the stream bed. All the attached zoobenthos and organic matter were quickly washed into Surber sampler. The collected specimens were then properly kept in sample bags for laboratory analysis.

Other than that, the environmental variables such as water depth, light intensity, water temperature and DO were measured for each sampling point. Appropriate equipments included foldable ruler, LICOR photometer and flexi meter (HQ 30d model) were used to measure the specified environmental variables.

## 2.3 Laboratory Analysis

Right after the field sampling, zoobenthic specimens of each collected sample were sorted out in the lab. All specimens were briefly observed and separated into groups according to their morphological characteristics. Then, from the grouping samples, each specimen was carefully observed by using stereomicroscope for identification up to Order classification (reference: 谷田一三 et. al. (2000) and Merritt & Cummins (1996)). According to sampling site, the number of specimen for each Order was calculated.

For aquatic insects, the feeding habit of each Order was identified referring to Merritt & Cummins (1996). In fact, it is impossible to see all species from the same Order to share the same feeding habit. Therefore, in this case, the feeding habit for each Order is defined by the majority condition (see Table 1). Ephemeroptera, as the grazer type aquatic insects, was apparently the targeted group in this research study.

**Table 1**: General feeding habits of aquatic insects (in Order Classification) that can be found in Kurokawa River, Japan.

| No. | Order Classification | General Feeding Habit |
|---|---|---|
| 1 | Ephemeroptera | Grazer |
| 2 | Odonata | Predator |
| 3 | Plecoptera | Predator |
| 4 | Megaloptera | Predator |
| 5 | Trichoptera | Mix Diet |
| 6 | Coleoptera | Mix Diet |
| 7 | Diptera | Filterer |

## 2.4 Data Analysis

The environmental conditions were analysed by using the photos and the measurements that recorded at the sampling points. As for the zoobenthic samples, the number of insect specimen for each feeding group (grazer, predator, filterer or mix diet) was confirmed and compared for each sampling site. Furthermore, the abundance of grazers was compared among habitats with the effects of habitat type and light availability. Lastly, all detected zoobenthos were listed for biodiversity investigation.

## 3. Results

### 3.1 Environmental Condition

Table 2 shows the visual conditions at the eight sampling points, which coded as RO 001, RO 002, RS 001, RS 002, PO 001, PO 002, PS 001 and PS 002. By checking the photos, it is obvious that the two quadrates for each sampling site were having similar light availability, water depth and current flow. Besides, the sampling points at PO and PS showed calmer water flow than RO and RS. Note that the growth of epilithic algae was found at every sampling point while the shaded points were detected with additional mosses (see the photos of RS 001and RS 002 in Table 2).

**Table 2:** Visual record of the environmental conditions at eight sampling points in Kurokawa River, Japan.

| No. | Habitat | Quadrate/Sampling Point | |
|---|---|---|---|
| | | 001 | 002 |
| 1 | RO |  |  |
| 2 | RS |  |  |
| 3 | PO |  |  |

| | | | |
|---|---|---|---|
| 4 | PS |  |  |

The sampling points were selected at similar water depth to reduce the impacts caused by the difference of water depth. According to Table 3, water depth was maintained less than 20 cm for all sampling points except RS 002 and PO 002. This is due to the difficulty in searching a more suitable sampling point within the small study area. In addition, it became harder in selecting shady habitat because the study area is largely exposed and the sunlight direction changes with time.

As expected, the light intensity was much higher at opened point; no matter it was riffle or pool habitat. However, the given measurements are only suitable for comparison purposes and shall not be regarded as accurate description of the environmental condition. This is because the light intensity is directly influenced by changes of weather and sunlight direction throughout the day. It is same to the measurement for water temperature. The readings of water temperature were higher in the opened sites than the shaded sites by only few degrees Celsius. As for DO, there was no much difference among sampling points, all ranged from 7 to 8 mg/L.

**Table 3**: Measurements of Environmental factors for each sampling point (quadrate) at Kurokawa River, Japan.

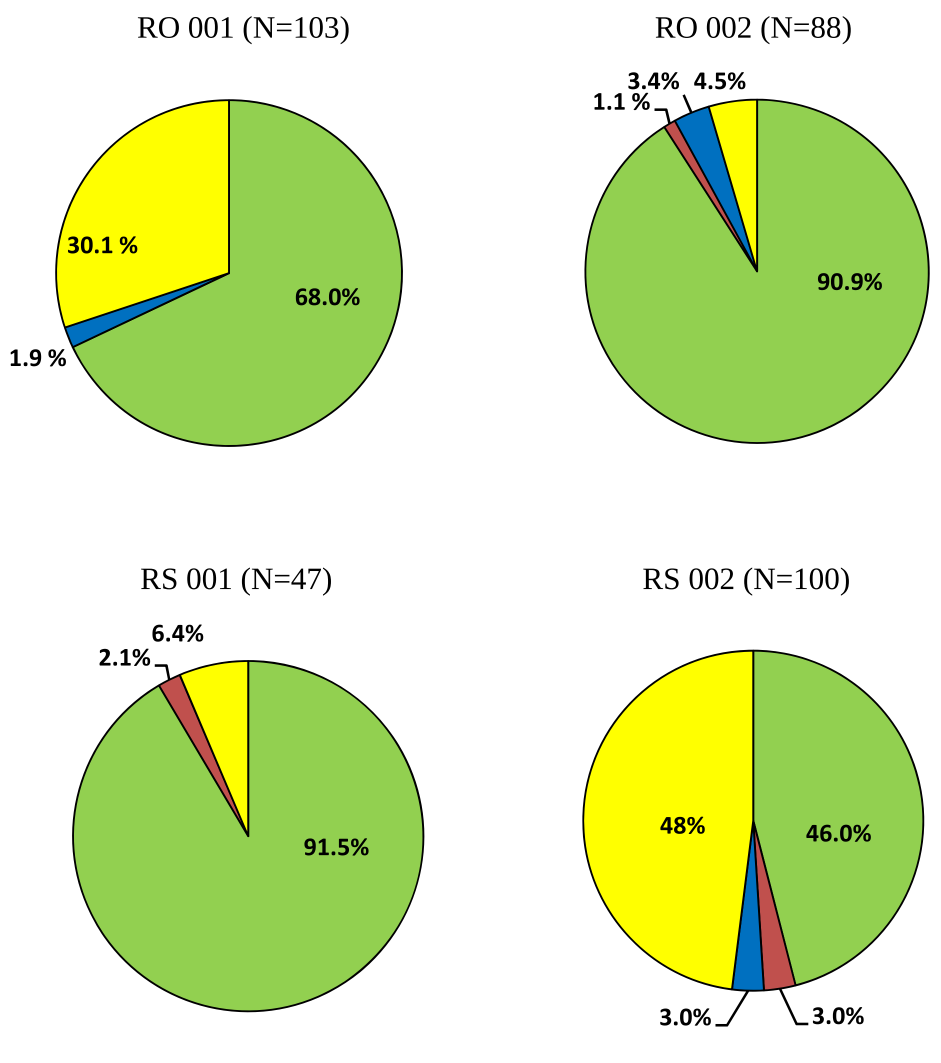
| **No.** | **Factor** | **Quadrate/Sampling Point** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RO 001 | RO 002 | RS 001 | RS 002 | PO 001 | PO 002 | PS 001 | PS 002 |
| 1 | Water Depth (cm) | 12.5 | 17.5 | 13.5 | 42.5 | 7.5 | 36.5 | 7.5 | 10.5 |
| 2 | Light Intensity (mmol) | 1667.8 | 1652.5 | 27.57 | 43.75 | 1725.2 | 1831.2 | 67.69 | 29.67 |
| 3 | Temperature (°C) | 21.9 | 23.0 | 18.9 | 18.9 | 21.8 | 21.2 | 20.8 | 20.0 |
| 4 | Dissolve Oxygen (mg/L) | 7.45 | 6.83 | 7.93 | 8.08 | 7.94 | 7.63 | 7.55 | 7.79 |

### 3.2 Comparison of Feeding Groups

The zoobentic communities settled on the exposed rocks are dominated by two feeding groups – grazers and mix diet insects (see Figure 2). Predators and filterers, however, occupy a small percentage (less than 10 %) in all cases.

The rocks from riffle habitat tend to have more grazers than mix diet insects while the two groups are similarly abundant for the rocks from pool habitat. Among the riffle sampling points, there is an exceptional case detected in RS 002, where the percentage of mix diet insects is slightly higher than the grazers that supposedly the dominant. This may be due to the different shape of sampled rocks. At the sampling point of RS 002, one or two of the sampled rocks has particular uneven surface and a lot of Tricoptera specimens (mix diet insects) were found and collected from the concave parts. Nonetheless, this may not a clue to relate the rock shape and abundance of Tricoptera.

Comparing the results of opened and shaded sites, there is no obvious difference in feeding group composition. Accordingly, the composition of feeding group on the exposed rocks may not directly affected by the light availability. The composition of feeding group is more likely to link with the habitat type where the water current is an important controlling factor.



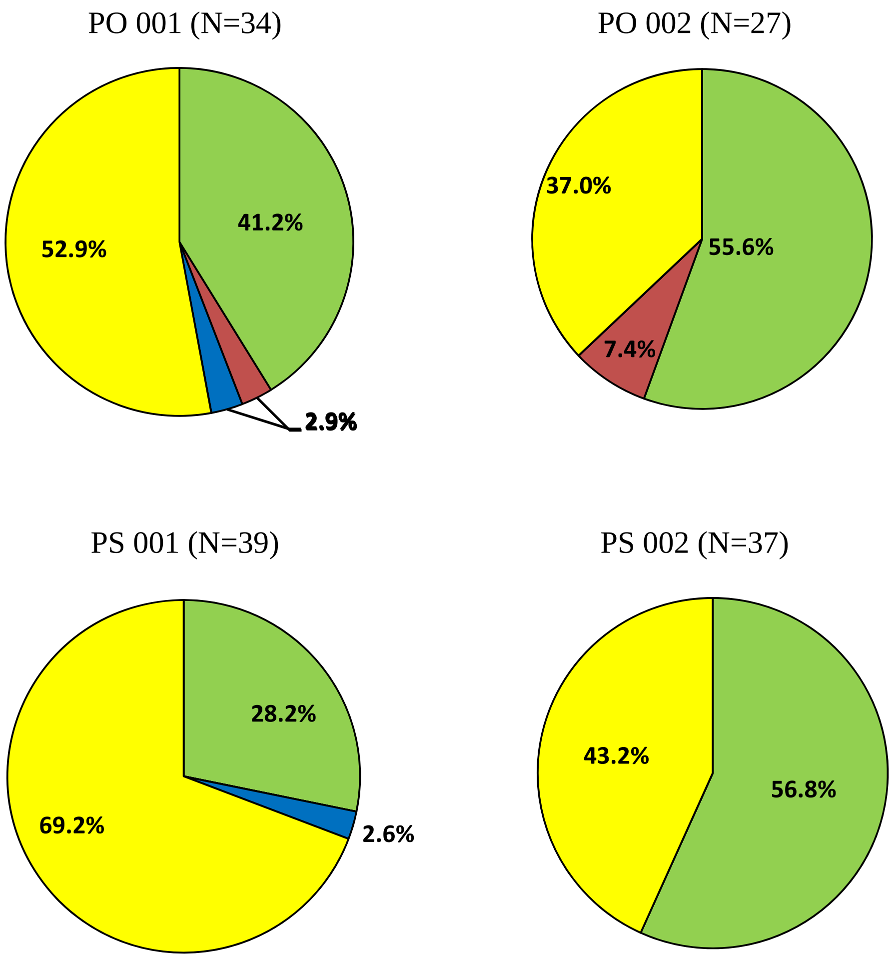



**Figure 2:** Percentages of each feeding group (green = grazer, yellow = mix diet, blue = filterer and red = predator) from the zoobenthos community at different sampling points.

### 3.3 Comparison of Abundance of Grazers

Figure 3 shows that there is no much difference in the number of grazing aquatic insects between the two points (001 and 002) of each sampling site. The maximum difference is only 10, which demonstrated by RO and PS.

The grazer numbers of both opened and shaded riffles are higher than those of pool sites. In detail, the abundance of grazers at RS is almost triple the PO and PS, and it is about half of the RS. The second sampling point of RO recorded the highest number of grazers while the first sampling point of PS presented the lowest record of only 11 grazers.

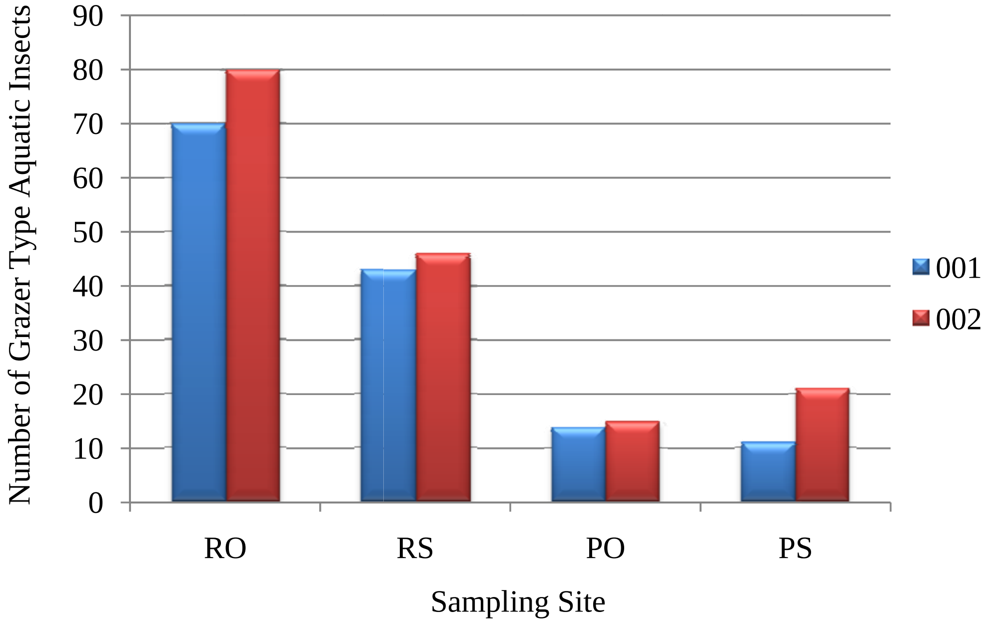



**Figure 3:** Comparison of the abundance of grazer type aquatic insects among sampling sites (RO, RS, PO and PS) and sampling points (001 and 002)**.**

The grazers are more abundant at riffle habitat regardless of light availability (see Figure 4). Though, it is not true to state that the grazers are more abundant in either opened or shaded area. In this case, there is an interaction and habitat type shall be considered. The grazers are significantly more abundant in the opened area for riffle habitat, but there is very little difference between opened and shaded areas for pool habitat.

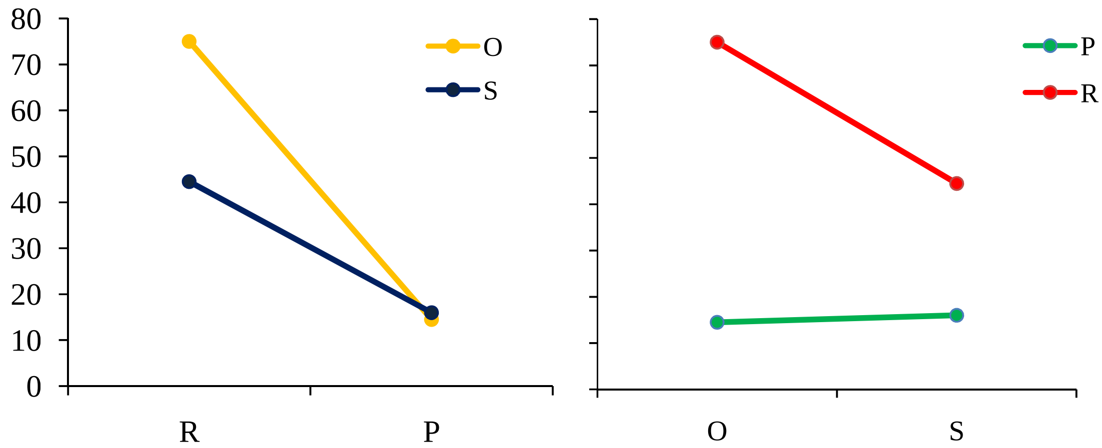



**Figure 4:** Relationship between habitat type (R = riffle, P = pool) and light availability (O = opened, S = shaded) for the abundance of grazers at Kurokawa River, Japan.

Referring to Table 4, there were five different Orders of aquatic insects, pupa (not identified) and non-insect zoobenthos (e.g. Hirudinea, Hydrachnellae and Oligochaeta) found from the collected samples. However, none of the sampling points was providing all types of freshwater zoobenthos. Besides, the examined zoobenthos communities were mostly formed by Ephemeroptera and Trichoptera. The Ephemeroptera, as the target group in this study, was largely consisted of Baetidae and Heptageniidae families.

The total number of zoobenthos at the riffle sites is apparently higher than the pool sites regardless of light availability. But, there is no specific trend between the opened and shaded sites. Even though there is higher number of zoobenthos at riffle sites, but it does not mean that the biodiversity is richer than pool sites. The zoobenthos diversity is similar across the sampling points where three to five different classifications could be detected.

**Table 4**: List of zoobenthos biodiversity for the sampling points (quadrate) at at Kurokawa River, Japan.

| No. | Classification | Quadrate/Sampling Point | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RO 001 | RO 002 | RS 001 | RS 002 | PO 001 | PO 002 | PS 001 | PS 002 |
| 1 | Ephemeroptera | 70 | 80 | 43 | 46 | 14 | 15 | 11 | 21 |
| 2 | Plecoptera | 0 | 0 | 1 | 3 | 1 | 2 | 0 | 0 |
| 3 | Megaloptera | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Trichoptera | 31 | 4 | 3 | 48 | 18 | 10 | 27 | 16 |
| 5 | Diptera | 2 | 3 | 0 | 3 | 1 | 0 | 1 | 0 |
| 6 | Pupa | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 7 | Non-insect | 3 | 0 | 0 | 5 | 0 | 1 | 4 | 0 |
| | **TOTAL** | **106** | **88** | **47** | **105** | **35** | **28** | **43** | **38** |

## 4. Discussion

There were several limitations in this study which may contribute to research errors. Firstly, the restricted extent of research area at Kurokawa River (about 200m in length) was limiting the search of ideal sampling points. Few of the selected sampling points did not completely fulfill the research criteria, such as PS 001 and PS 002 that were not totally shaded (see Table 2). Regrettably, a more suitable sampling point could not be found within the small study area.

Second is the time and manpower constraint. This is a three days study carried out primarily by personal efforts. Therefore, the experimental replication in field as well as the analytical progress in lab was restricted. For instance, identification of zoobenthos up to Family classification is preferably to provide more information, if research time and manpower is sufficient.

In addition, the laboratory work was only conducted at Kiso Biological Station of Kyoto University and thus analysis of samples was dependent on the available equipment at the station. In this study, measurement of algal biomass was given up from the research plan due to lack of necessary equipment, a functional spectrophotometer. Otherwise, it will be a more appropriate method to study the relationship between light availability and abundance of grazers in the river.

For a detailed study on this topic, several suggestions are proposed to improve the result accuracy and consistency. Time management and planning are important to launch a scientific research, particularly those of field studies involving live specimens. Both field and laboratory work shall be timely completed with intensive attempt to reach the maximum requirements within capacity.

In the field, it is necessary to be extra careful and considerable in choosing a suitable sampling site for minimizing associated errors. Repetition of work or increasing sample size is also one of the ways. Apart from that, forming partnership or research team is highly recommended. This is not only for research needs, but also for safety issue in the field.

## 5. Conclusion

There is an interaction found between habitat and sunlight availability. The grazers are significantly more abundant in the opened area for riffle habitat, but there is little difference between opened and shaded areas for pool habitat. In comparison to light availability, habitat type seems to be a stronger indicator of the abundance of grazers in Kurokawa River, Japan. More scientific findings are needed to examine the proposed hypothesis.


## 6. Acknowledgement

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