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**Amusan Babatunde**
Department of Zoology,
Obafemi Awolowo University,
Ile-Ife, Nigeria

**Balogun Ibukunoluwa**
Department of Zoology,
Obafemi Awolowo University,
Ile-Ife, Nigeria

**Correspondence**
**Amusan Babatunde**
Department of Zoology,
Obafemi Awolowo University,
Ile-Ife, Nigeria

# Assessment of the aquatic insect assemblage and water quality of a tropical stream in Southwestern Nigeria

**Amusan Babatunde and Balogun Ibukunoluwa**

**Abstract**
The aquatic insect fauna of Aho stream was studied in relation to certain physico-chemical parameters with a view to determining the impacts of anthropogenic activities on the insect assemblage. Two sampling stations with varying degree of anthropogenic activities were established for insect collection. Aquatic insects were sampled with the aid of a D-frame net between October, 2016 and February, 2017. Station 1 was not only higher in terms of diversity and species richness, it was also greater in abundance as it accounted for 70% of the total insect collection. There were significant differences in the composition and abundance of insects in the two stations ($p<0.05$). Although, regression analysis revealed variations in the values of the physico-chemical parameters, however, the observed differences were not statistically significant ($p>0.05$). In conclusion, the difference in the abundance and composition of insects in the stations was influenced by factors other than the physico-chemical parameters of the water.

**Keywords:** Aquatic insects, water quality, abundance, composition, richness

## 1. Introduction

Aquatic insects are a diverse group amongst macroinvertebrates and they comprise about 95% of the total species of macroinvertebrates [1]. They are widely distributed in several orders, which are either aquatic at certain stages of their life-cycle or spend their entire life in or around waterbodies [2]. The distribution, diversity, high reproduction rate, short generation time and rapid colonization of freshwater habitats by aquatic insects have made them useful as bio indicators of the health and quality of freshwater systems [1]. Furthermore, aquatic insect assemblage and diversity have been known to be greatly influenced by variations in physico-chemical parameters of the water [3, 4]. Changes in physico-chemical properties may cause disruption in biological activities, trophic levels, feeding habits and migrations or imposes physiological stress on even the tolerant species. The nature of the distribution provide a preliminary information on the ecological processes and environmental parameters that govern the populations and communities of macroinvertebrates in a particular waterbody [5, 6].

Physico-chemical parameters such as turbidity, flow patterns, water temperature, riparian cover, dissolved oxygen, biochemical oxygen demand, pH, hardness, nutrients and metals have been used alone to assess water quality [7, 8]. However, such parameters does not reflect the long term pollution effects and other ecological stress on the biotic community but only provides information on the physical state of a waterbody which may be of no ecological significance [7]. On the contrary, aquatic insects (especially the immature stages) which are found at the base of food chain such as scrapers and shredders provide information on the ripple effects of environmental stress responsible for changes in the physico-chemical properties of the water [9, 5]. This crucial role played by the aquatic insects in the ecosystem has made them the preferred indicator in the study of the ecological significance of stress. Another factor which has enabled aquatic insects as bioindicators of water quality is their varying level of tolerance to environmental disturbance [10]. Waterbodies are variously impacted by urbanization, ions, agriculture, pastures and deforestation [11, 12] and this causes varying degree of stress. Consequently, the insects are distributed in these waterbodies with respect to their level of tolerance.

In Nigeria, the ecological integrity of river systems are being threatened by changes in land-use and other anthropogenic activities which causes harmful effects on water quality, stream habitat and aquatic invertebrate's biodiversity depending on the type, concentration and duration of exposure. Moreso, studies on aquatic insects in Nigeria have shown variations in abundance and composition with respect to water quality [13, 18]. These variations were generally attributed to different levels of exposure of the water bodies to anthropogenic activities and other stress factors. Aho stream is greatly impacted by anthropogenic activities such as farming, logging of woods and recreational activities. Hence, this study seeks to investigate the impacts of these anthropogenic activities on the aquatic insect fauna of this water body. This study hypothesize that the aquatic insect assemblage of the stream is greatly impacted by anthropogenic activities within its basin. It is expected that findings in this study would provide baseline information for future management practices of the stream and the entire parks and garden.

## 2. Methodology

### 2.1 Study Site

Aho stream runs through the Parks and Garden, located within Obafemi Awolowo University, Ile-Ife campus. The stream covers between $07^0\,30^{'}\,37^{''}$ N and longitude $004^0\,32^{'}\,4^{''}$ E. The vegetation is typical of the tropical rainforest region of Africa. The stream is narrow and the flow rate is moderately high. For the purpose of this study, two sampling stations were established based on the perceived level of anthropogenic disturbances. The first station (Station 1) was located upstream while the other (Station 2) was located downstream. Station 1 was devoid of observable anthropogenic activities while station 2 received effluent directly from the farmland located in the garden. Washing of farm tools and bathing were also observed around station 2.

### 2.2 Sampling, preservation and identification of specimens

Sampling of aquatic insects was carried out between October, 2016 and February, 2017. The aquatic insects were collected monthly with the aid of D-frame and deep nets. The nets were used to scoop the surface water, the substratum and the riparian vegetation around the stream. The insects collected were sorted in white trays with the aid of a pair of forceps. The specimens were preserved in well labeled sampling bottles containing 70% ethanol. The specimens were identified to possible taxonomic levels using appropriate identification keys and guides [20, 21].

### 2.3 Water Sampling

Water samples were also collected on each sampling occasion for the analysis of some selected physico-chemical parameters. Water temperature was determined in situ with the aid of a mercury in glass thermometer (model P456). The thermometer was immersed in the water for about 3-5 minutes and at three different locations and the average reading was taken. The pH was determined using a digital pH meter (model EIL 3055). Other parameters such as conductivity, total dissolved solids (TDS), total alkalinity, dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined according to APHA methods.

### 2.4 Data analysis

Taxa richness, species diversity and richness were calculated using Shannon, Margalef and evenness indices respectively on PAST (Patheological statistical package; version 3.14).The mean abundance of the insect orders and the physico-chemical parameters for the two sampled stations were compared for significant differences using one-way analysis of variance (ANOVA). Pearson Correlation Coefficient (r) was used to evaluate the relationship between the physico-chemical parameters and the abundance of insect orders. Mean differences and correlation coefficient were done using Statistical Package for Social Sciences (SPSS version 20).

## 3. Results

### 3.1 Composition and abundance of aquatic insects

A total of 421 individuals (ind.) of aquatic insects represented by 17 taxa in 7 orders were collected during the study. Station 1 accounted for 298 individuals (71%) represented by 13 taxa distributed in 5 orders. As shown in Table 1, Order Ephemeroptera was dominant as four (4) different genera in this order were collected. Ephemeroptera was equally the most abundant order as it accounted for a total of 107 individuals (i.e 36% of the collections in Station 1 and 25% of the entire insect collection). However, *Oreotochilus sp* (Coleoptera) was the dominant and most abundant species as it accounted for 23% of the collections in station 1 while *Dinectus sp* was the least abundant in the station as it accounted for 3% of the collections in the station. Station 2 accounted for 123 individuals (29%) represented by 8 taxa distributed in 4 orders. Odonata was the dominant and most abundant order in this station as it accounted for the highest number of taxa (3) and individuals (52) (42%) respectively. The least diverse order was the Lepidoptera as it was represented only one species. *Enallagma sp* was the most abundant species as it accounted for 17% of the insect collections in this station.

Table 2 revealed that there were observed variations in the composition and abundance of the recorded orders in the two sampled stations. The differences between the stations were statistically significant ($p$<0.05) except for the order Odonata which did not show significant difference in the two stations.

### 3.2 Diversity indices

The results of the diversity indices are shown in Table 3 as thus; Margalef richness index (d) values obtained for stations 1 and 2 are 2.106 and 1.455 respectively while Shannon's diversity index values for stations 1 and 2 are 2.371 and 2.012 respectively. Evenness values were 0.8235 and 0.9351 for stations 1 and 2 respectively while Simpson's dominance was 0.8863 and 0.8615 for stations 1 and 2 respectively. However, the EPT index value obtained was 0.4530 for station 1 and 2 respectively. These indices were higher in station 1 than in station 2 except for evenness which was higher in station 2.

As shown in Table 4, One way analysis of variance (ANOVA) carried out to evaluate the differences in the values obtained for the physico-chemical parameters of the water revealed that there were observable variations in the values but the differences were not statistically significant ($p$>0.05).

### 3.3 Correlation relationships.

Pearson correlation coefficient (r) relationship between the insect orders showed strong relationships amongst the insect orders. Table 5 revealed that the correlation relationships were both positive and inversely while a good number of the relationships were significant. For instance, Ephemeroptera had a positive relationship with Trichoptera (r = 0.936, $p$<0.01) and Coleoptera (r = 0.799, $p$<0.05) inversely related with Lepidoptera (r = -0.724, $p$<0.05) and Diptera (r = -0.925, $p$<0.01). Trichoptera showed a positive relationship with Coleoptera (r = 0.894, $p$<0.01) and Hemiptera (r= 0.779,

$p<0.05$) and inverse relationship with Lepidoptera (r = -0.756, $p<0.05$) and Diptera (r = -0.966, $p<0.01$). Coleoptera had a positive relationship with Hemiptera (r= 0.781, $p<0.05$) and an inverse relationship with Lepidoptera (r = -0.708, $p<0.05$) and Diptera (r = -0.904, $p<0.01$).

Pearson correlation coefficient (r) relationship between the physico-chemical parameters and the insect orders were generally weak. Only Odonata showed significant correlation with Conductivity (r = -0.734, $p<0.05$) and TDS (r = -0.841, $p<0.05$) while the other correlations were weak and insignificant. The correlation relationships were both positive and inverse but majorly insignificant.

## 4. Discussion

Taxa richness and abundance of individuals collected in this study indicated that Aho stream can be considered fairly rich and the stream compares favourably with reports of similar waterbodies in this region [16, 23]. The insect composition and the values recorded for the physico-chemical parameters of the water are similar to [41, 42] where fairly high abundance of insects were also recorded with respect to the water quality and size of the stream. The relatively high species richness observed in this study may be attributed to the availability of suitable microhabitats conditioned by less anthropogenic disturbances within and around the steam basin [24]. The vast occurrence and abundance of Odonata in the two sampled stations may be attributed to their diverse feeding pattern and the abundance of aquatic vegetation which have been known to provide good oviposition sites for the members of this order [25, 7]. The EPT index has been widely used as indicators of water quality because they are highly sensitive to pollution [8]. The abundance of Ephemeroptera, Trichoptera and Coleoptera in station 1 is an indication of the good quality of the water. The abundance of *Orectochilus* sp in staion 1 further confirms the good quality of the water. This species are known to prefer well aerated, clean and slow moving water. They are also known to clean the water surfaces of debris and improve transparency of the water [26]. The high number of the *Orectochilus* sp collected in this stream is also not surprising as it has been reported to be commonly found in clean ponds and streams in Nigeria [27]. The high number of *Orectochilus* sp collected is similar [43] in which abundance of this beetle was also recorded in the study. However, the abundance of members of the order Diptera and the poor representation of the EPT complex in station 2 could be an indication of point source pollution [28, 7]. Apart from the fact that station 2 is prone to pollution stress, the stony substratum may also account for the fewer number of insects collected in the station. This finding corroborates the observation of [29] which reported that stony substratum limits the abundance of insect in a water body. The occurrence of members of Lepidoptera in station 2 may be due to the abundance of flowering plants within the parks and gardens. The stream provides a good habitat for the immature stages of the members of the order Lepidoptera [30].

The diversity and species richness indices all reported values greater in station 1 than station 2. This is an indication that diversity and species richness was higher at station 1. This may be due to the fact that station 1 is exposed to less anthropogenic stress. As such, the variation in diversity and species richness in the sampled stations may be attributed to the varying degree of exposure to pollution stress [24]. Also, the range of values obtained for the Margalef's water quality index was between 1 and 3 and this further indicated moderate pollution in the stream [31].

### 4.1 Physico-chemical parameters

Variations in physico-chemical parameters have been identified as one of the important factors affecting the distribution of insects in water bodies [32]. Although, there were variations in the investigated physico-chemical parameters in the two stations, however, the differences were not statistically significant ($p>0.05$). This is an indication that the stations were not too different in terms of their water quality. Apart from the BOD values that were close to the limit (4.0 mg/L) recommended for aquatic organisms [33], the range of values obtained for the physico-chemical parameters of the stream fell within the optimal range for tropical inland waterbodies [34, 23, 35]. The observed high BOD values may be attributed to wastes from agricultural and domestic sources (including organic and inorganic matter) received by the stream [36].

### 4.2 Relationship between Physico-chemical parameters and Aquatic insect orders.

There was no clear pattern in the relationship between the physico-chemical parameters and the insects collected in the stream. Moreover, it is surprising that the two sampled stations differ significantly in terms of composition and abundance of the insects but the physico-chemical parameters showed that the stations were not too different as no significant differences were obtained in the values. This finding is an indication that the observed differences in the composition and abundance of insects in the two stations might be influenced by factors other than physico-chemical parameters of the water. Many studies have reported low correlation between insects and physico-chemical parameters and this has been attributed to wide range of adaptability of insects to changing environments [37, 15, 38]. This implied that the insects could have acquired adaptive mechanisms to enable them survive various environmental conditions in and around the waterbody. [39] observed a similar trend in the study carried out on the physico-chemical factors affecting aquatic insects in Okhuo River, Benin city. The study concluded that aquatic insects' distribution is often affected by the availability of food and shelter rather than physical and chemical parameters of the water. Another study which assessed the effects of anthropogenic activities on physico-chemical parameters and aquatic insects of Mara River in Kenya by [40] revealed that only total dissolved solids (TDS) was predictive of the insects in the waterbody while other physico-chemical parameters were not. Therefore, it is safe to note that the difference in the stations in terms of composition and abundance of insects was not influenced by variations in the physico-chemical parameters of the water.

**Table 1:** Composition and abundance of aquatic insects in Aho stream, O.A.U, Ile-Ife.

| Taxa | Stations | | Total |
|---|---|---|---|
| | 1 | 2 | |
| **Ephemeroptera** | | | |
| Caenis sp | 43(14.43%) | 0 | 43(10.21%) |
| Belostoma sp | 18(6.04%) | 0 | 18(4.28%) |
| Cleon sp | 30(10.07%) | 0 | 30(7.13%) |
| Baetis sp | 16(5.37%) | 0 | 16(3.80%) |
| Sub-total | 107(35.91%) | 0 | 107(25.42%) |
| **Odonata** | | | |
| Lestes sp | 18(6.04%) | 16(13.01%) | 34(8.08%) |
| Enallagma sp | 25(8.39%) | 21(17.07%) | 46(10.93%) |
| Trithemis sp | 10(3.36%) | 0 | 10(2.38%) |
| Ceriagrion sp | 0 | 15(12.2%) | 15(3.56%) |
| Sub-total | 53(17.79%) | 52(42.28%) | 105(24.94%) |
| **Trichoptera** | | | |
| Ceraclea sp | 12(4.03%) | 0 | 12(2.85%) |
| Stenopsyche sp | 16(5.37%) | 0 | 16(3.80%) |
| Sub-total | 28(9.40%) | 0 | 28(6.65%) |
| **Coleoptera** | | | |
| Orectochilus sp | 68(22.82%) | 0 | 68(16.15%) |
| Dinectus sp | 8(2.68%) | 0 | 8(1.90%) |
| Sub-total | 76(25.50%) | 0 | 76(18.05%) |
| **Hemiptera** | | | |
| Hydrometra sp | 22(7.38%) | 12(9.76%) | 34(8.08%) |
| Eurymetra sp | 12(4.03%) | 4(3.25%) | 16(3.80%) |
| Sub-total | 34(11.41%) | 16(13.01%) | 50(11.88%) |
| **Lepidoptera** | | | |
| Nymphula sp | 0 | 18(14.63%) | 18(4.28%) |
| Sub-total | 0 | 18(14.63%) | 18(4.28%) |
| **Diptera** | | | |
| Simulium sp | 0 | 17(13.82%) | 17(4.04%) |
| Anopheles sp | 0 | 20(16.26%) | 20(4.75%) |
| Sub-total | 0 | 37(30.08%) | 37(8.79%) |
| Total | 298 | 123 | 421 |

**Table 2:** Analysis of variance of abundance of aquatic insects in Aho stream, O.A.U, Ile-Ife.

| Orders | Station 1 | Station 2 | | | Overall |
|---|---|---|---|---|---|
| | (min-max) mean±S.D | (min-max) mean±S.D | F | P | (min-max) mean±S.D |
| Ephemeroptera | (21-37) 26.75± 7.32 | - | 53.417 | 0.000* | (0-37) 13.38± 15.080 |
| Odonata | (11-15) 13.25± 1.708 | (7-18)13.00± 5.354 | 0.008 | 0.932 | (7-18) 13.13± 3.682 |
| Trichoptera | (6-8) 7.00± 0.816 | - | 294 | 0.000* | (0-8) 3.50± 3.780 |
| Coleoptera | (11-24) 19.00± 6.272 | - | 36.712 | 0.001* | (0-24) 9.50± 10.954 |
| Hemiptera | (6-11) 8.50± 2.380 | (2-6) 4.00± 1.826 | 9.000 | 0.024* | (2-11) 6.25± 3.105 |
| Lepidoptera | - | (1-8) 4.50± 3.109 | 8.379 | 0.028* | (0-8) 2.25± 3.151 |
| Diptera | - | (7-11) 9.25± 1.708 | 117.34 | 0.000* | (0-11) 4.63± 5.069 |

* = significant ($p<0.05$)

**Table 3:** Diversity and species richness indices of aquatic insects in Aho stream, Ile-Ife.

| | Station 1 | Station 2 |
|---|---|---|
| No of Taxa/ Species | 13 | 8 |
| No of Individuals | 298 | 123 |
| Shannon Diversity (H') | 2.371 | 2.012 |
| Evenness Index (E) | 0.8235 | 0.9351 |
| Margalef's index (Taxa richness) | 2.106 | 1.455 |
| Simpson's Dominance | 0.8863 | 0.8615 |
| EPT Index | 0.4530 | 0 |

**Table 4:** Mean concentrations of the physico-chemical parameters of Aho stream.

| Parameters | Station A | Station B | | | Overall |
|---|---|---|---|---|---|
| | (min-max) mean ± S.D | (min-max) mean ± S.D | F | P | (min-max) mean ± S.D |
| DO(mg/L) | (4.6-7.6) 6.35± 1.3 | (6-6.8) 6.4± 0.46 | 0.005 | 0.945 | (4.6-7.6) 6.375± 0.903 |
| Alkalinity | (34-73) 48.5± 17.18 | (37-73) 51± 15.49 | 0.047 | 0.836 | (34-73) 49.75± 15.20 |
| Temp(°C) | (23.6-26) 24.93± 1.05 | (23.5-26.8) 25.13± 1.37 | 0.053 | 0.825 | (23.5-26.8) 25.03± 1.14 |
| Conductivity | (95.1-215) 147.2± 50.75 | (86.7-214) 130.3± 58.5 | 0.193 | 0.676 | (86.7-215)138.76±51.51 |
| pH | (6.2-9.2) 7.437± 1.275 | (6.2-8.7) 7.3± 1.055 | 0.028 | 0.873 | (6.2-9.2) 7.368± 1.086 |
| TDS | (63.4-143) 98.28± 33.69 | (57.7-142) 86.8± 38.60 | 0.201 | 0.670 | (57.7-143) 92.54± 34.10 |
| BOD | (1.4-5.6) 3.05± 1.821 | (1.8-3.8) 3.1± 0.945 | 0.002 | 0.963 | (1.4-5.6) 3.075± 1.345 |

* = significant ($p<0.05$)

**Table 5:** Correlation relationship between the aquatic insects and the physico-chemical parameters of the stream.

| | EPH | ODO | TRI | COL | HEM | LEP | DIP | DO | ALK | TEMP | CDTY | pH | TDS | BOD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPH | 0 | | | | | | | | | | | | | |
| ODO | 0.074 | 0 | | | | | | | | | | | | |
| TRI | 0.936** | 0.026 | 0 | | | | | | | | | | | |
| COL | 0.799* | -0.041 | 0.894** | 0 | | | | | | | | | | |
| HEM | 0.590 | -0.291 | 0.779* | 0.781* | 0 | | | | | | | | | |
| LEP | -0.724* | 0.477 | -0.756* | -0.708* | -0.840** | 0 | | | | | | | | |
| DIP | -0.925** | -0.211 | -0.966** | -0.904** | -0.683 | 0.624 | 0 | | | | | | | |
| DO | 0.221 | 0.353 | -0.096 | 0.085 | -0.588 | 0.223 | -0.034 | 0 | | | | | | |
| ALK | -0.223 | -0.518 | -0.022 | -0.134 | 0.398 | -0.183 | 0.216 | -0.816* | 0 | | | | | |
| TEMP | -0.190 | -0.403 | -0.110 | -0.085 | 0.455 | -0.425 | 0.227 | -0.553 | 0.519 | 0 | | | | |
| CDTY | 0.015 | -0.734* | 0.239 | 0.215 | 0.551 | -0.417 | -0.035 | -0.748* | 0.851** | 0.297 | 0 | | | |
| pH | 0.078 | 0.023 | 0.109 | 0.142 | -0.281 | 0.282 | -0.162 | 0.229 | -0.294 | -0.873** | 0.066 | 0 | | |
| TDS | 0.018 | -0.841* | 0.242 | 0.220 | 0.553 | -0.420 | -0.038 | -0.747* | 0.847** | 0.295 | 1.000** | 0.068 | 0 | |
| BOD | -0.076 | -0.181 | -0.115 | 0.046 | 0.296 | -0.262 | 0.118 | -0.135 | 0.229 | 0.747* | 0.003 | -0.832* | 0.001 | 0 |

(EPH - Ephemeroptera, -ODO – Odonata, TRI – Trichoptera, COL - Coleoptera, HEM - Hemiptera, LEP - Lepidoptera, DIP - Diptera, DO - Dissolved Oxygen, ALK - Alkalinity, TEM - Temperature, CON - Conductivity, pH, TDS - Total Dissolved Solute, BOD - Biological Oxygen Demand)

* significant ($p$<0.05), 2-tailed, ** significant ($p$<0.01)

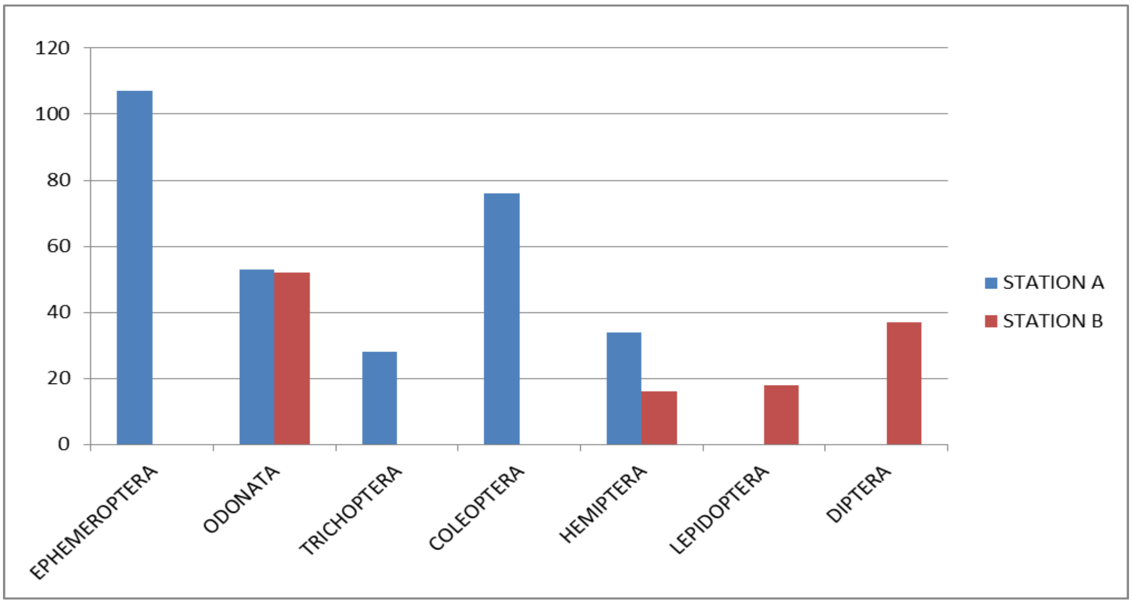


**Fig 1:** Comparative abundance of aquatic insects in the two stations in Aho stream

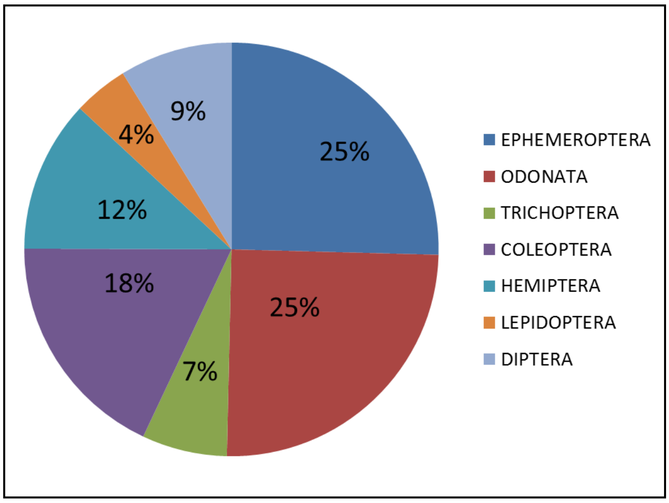


**Fig 2:** Variations in the composition of insect orders in Aho stream

## 5. Conclusion

In conclusion, the stream studied can be considered relatively rich in terms of abundance and species composition. The observed variations in the physico-chemical parameters of the water body did not account for the significant differences in species composition in the two sampled stations. This indicated that the variation in the two stations was influenced majorly by factors other than the physico-chemical parameters of the water. The abundance of dipterans in station 2 is indicative of point source pollution in the stream. Therefore, conservation efforts towards regulating anthropogenic activities in the park are recommended in order to keep the water body in pristine condition.

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