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The aquatic insects of selected tilapia ponds in the North-western slope of Mt. Arayat, Pampanga, Philippines

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Abstract
The study was conducted to determine the composition, abundance, diversity and the correlation of water quality variables to the number of species and abundance of insects of the selected pond ecosystems located in the North-western slope of Mt. Arayat in Maglang, Pampanga. A total of 28 species belonging to 7 orders were observed throughout the sampling period. *Anisops* sp. dominated the insect community as evident by its high relative abundance in between seasons. Higher species diversity index (H') was obtained during dry season. Results indicated unequal distribution {J' = 0.79 (wet) - 0.84 (dry)} of individuals from each species in the community as evident also by the dominance {CD = 39.55 (wet) – 35.71 (dry)} of a single species. Meanwhile, the result showed high species similarity (QS = 0.956) between seasons. The studied water quality parameters showed a positive relationship to the number of species observed and their abundance except for TDS and number of species between seasons.

Keywords: Aquatic insects, *Anisops* sp., abundance, diversity, similarity and water quality

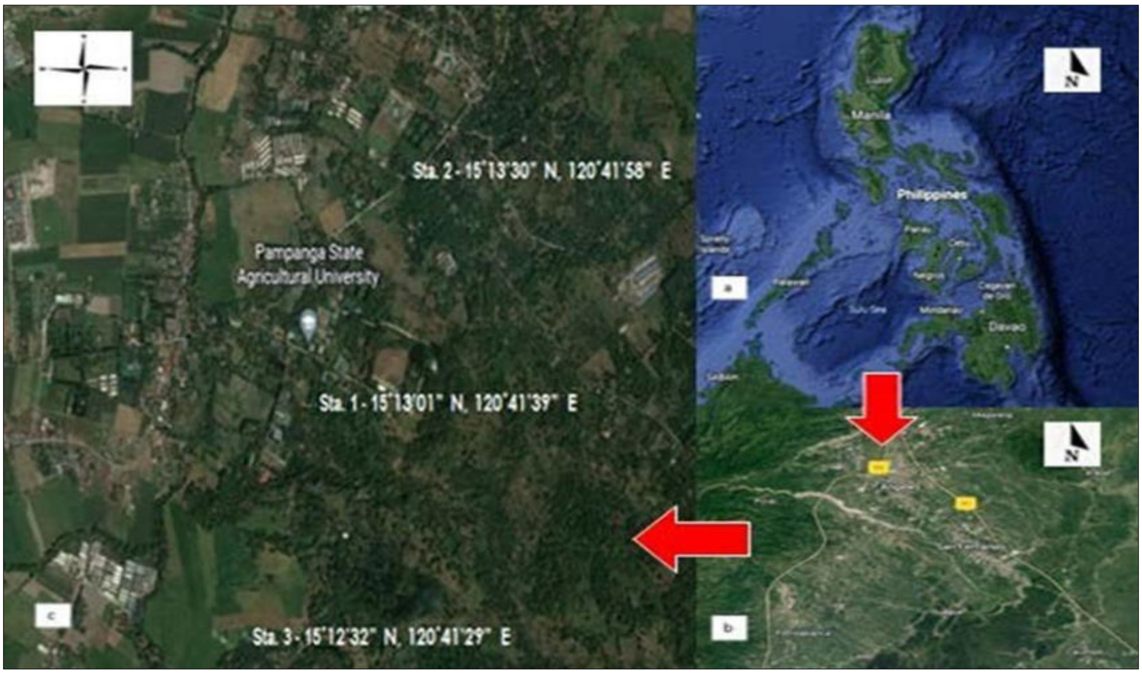
Introduction

Aquatic environments played a significant role as breeding and nursery grounds for various groups of insects. Worldwide, there were 45,000 species of insects known to inhabit freshwater ecosystems [1]. They belong to 12 orders of true insects that are aquatic and semiaquatic in a portion or all of their life stages [2]. However, these species only account for less than 4% of the total insect fauna which became terrestrial or aerial in nature after metamorphosis. Insects form an important component of the natural food web [3]. These insects are also involved in nutrient cycling and are important bioindicators of aquatic health [4]. As a food source, it benefitted various species of fish and other aquatic wildlife [5, 1]. However, some species are predatory that causes minimal mortality to fish particularly in their larval stages such as spawn, fry and fingerlings [6, 7]. Moreover, their contributions are now viewed beyond the trophic radius of aquatic animals. Some aquatic populations are now harvested because of their potential to contribute to the diet of increasing human population [2]. The North-western slope of Mount Arayat can be considered an agricultural hub of which production is dominated by rice farming. Fish farming also showed significant increase in the area using earthen ponds. Operation of most pond units located along the north-western slope is throughout the year due to sufficient supply of water from springs. However, some farmers in the area are relying mainly on rainfall and pumping underground water to support their operation throughout the year. The concrete roles of these ponds in the contribution to maintain local biodiversity of aquatic invertebrates like insects were still undetermined. Although it was often cited that water quality has great influence on the insect community, the management strategies employed in ponds could still be the primary determinant factor for the growth and survival of insects in the system. Ponds constructed in this area are devoted to tilapia production with almost similar levels of management. Farm management includes pond preparation, stocking, feeding, monitoring and harvesting. Ponds are subjected to the effect of seasonal changes. These changes can be manifested in the level of important water quality parameters that could influence abundance and diversity of aquatic organisms. In general, the province of Pampanga has two seasons – wet and dry. Wet season is characterized by the higher rate of typhoon occurrence causing heavy rains and coincides with the southwest monsoon.

Meanwhile, dry season is characterized by limited rainfall and warmest period can be experienced from March to April of each year. A recent study in the area showed relatively high richness of planktonic organisms during wet and dry seasons [8]. Plankton abundance is considered an important attribute that could support insect biodiversity [9]. Ponds, both natural and artificial units, are considered important in the conservation of local insect diversity [10, 11]. However, bodies of water subjected to restocking, the level of management, species cultured and the size of stock population could influence the structure of aquatic insect communities [12]. In order to understand the dynamics of the insect community associated with tilapia ponds in the area, some population parameters must be considered such as composition, diversity and abundance. Hence, this study was conducted to provide some important information on the status of aquatic insects present or left during the production period of tilapia in selected ponds along the slope of Mount Arayat.

Materials and Methods Sampling Site

The study was conducted in selected tilapia ponds located in the North-western slope of Mt. Arayat in Pampanga. Sampling stations were established as replications in the Pampanga State Agricultural University Inland Fisheries Project (Sta.1) and private farms located in Brgy. Ayala (Sta. 2) and Brgy. San Vicente (Sta. 3). Two pond units from each station were selected for water quality monitoring and sample collection.



Legend: a. Philippine map; b. Pampanga map; and c. location of the sampling sites

Fig 1: Map of the sampling sites (exported from Google Earth)

Collection of Samples

Sample collection was made thrice a month from July to September, 2020 (Wet Season) and February to April, 2021 (Dry Season). Samples were taken from each station using a modified tilapia fry collector (net with 300 microns mesh size). The anterior of the handle was provided with a glider to facilitate pushing and the net was attached to the handle with a distance of one foot from the glider to minimize the capture of sediments. The mouth has a diameter of 1.2 m and length of 2.0 m. The insect collector was pushed thrice at a certain distance (20 m). After each haul, the net was detached from the handle and brought near the dike. The plant debris, macrophytes (*Azolla*, duckweed, water lettuce and duck lettuce) and algae were removed and rinsed to reduce the amount of sediments. Presumed insects were picked from the net using tweezers and were placed in vials with 10 ml capacity. The samples were fixed in 20% formalin and taken to the laboratory for identification and counting.

Water Quality Assessment

The level of important water quality parameters such as temperature, dissolved oxygen (DO), pH and total dissolved solids (TDS) were measured using digital equipment during the collection and assessment of aquatic insects. Temperature and DO was measured using handheld Extech DO meter (Extech Instruments, New Hampshire). Meanwhile, pH and TDS were assessed using RCYAGO pen type pocket digital devices (Shenzen Yage Technology Limited, China).

Species Identification and Counting

Online materials published by Subramanian and Sivaramakrishnan [13] and Pelingen *et al.* [14] were used as reference for the identification process. Representative samples were taken from the vials and placed in a dissecting pan. The structure of the insects was observed using a magnifying glass. Photographs were taken for documentary purposes and comparison to the published materials. Counting of individuals from each species was made by taking all the individuals that were collected in both seasons.

Determining Diversity and Species Similarity

The diversity of aquatic insects in the 3 stations was expressed in terms of species richness (SR = S-1/logN), Shannon-Weinner Diversity index (H' = -Σ pi*log pi), and Pielou's evenness index (J' = H'/logS). In terms of dominance, the simple community dominance index (CD = y1 + y2/y) formula of McNaughton was used. The similarity of species was evaluated using the Sorensen's similarity index (QS = 2c/a+b).

Statistical Analysis

The relationship of number of species and overall abundance to temperature, dissolved oxygen, pH and total dissolved solids was determined using the Pearson moment correlation. All analyses were made with the aid of Microsoft Excel ver. 2010.

Results and Discussion Occurrence and Abundance

A total of 1,577 individuals were collected from the established stations during the course of the study. As shown in Table 1, these individuals belong to 28 species of the 7 distinct orders of aquatic insects. Order-wise distribution, it can be noted that Coleoptera, Hemiptera and Odonata have the highest representative species identified in the ecosystems covered in this study.

Meanwhile, Lepidoptera and Trichoptera have the least number of identified members. As to their occurrence, most species occurred in both seasons. In terms of mean overall abundance, higher number of individuals was observed in the dry season (Figure 1). Meanwhile, assessment of relative abundance revealed that *Anisops* sp. or commonly known as backswimmers dominated the insect community in the area in both seasons (Figure 2 and 3). However, relative abundance of this species and other major aquatic insects varied as to season. The result also showed that Hemipterans are abundant during the wet season and the abundance of Odonatans increased during the dry season.

The study showed that pond ecosystems located in the North-western slope of Mt. Arayat are playing an important role in contributing to aquatic biodiversity despite of their function in tilapia production. Based on the result of the study, a total of 28 species belonging to 7 orders are present in the study area. Inland waters including ponds harbor nearly 100,000 species belonging to 12 orders which spent part of their life in freshwater environments [15]. Although aquatic environments are playing a significant role in their survival, only 4% of the total insect community spent their entire lives in water [16]. Insect communities in freshwater ponds are composed of adult and larval individuals. At the larval stage, they constituted the huge portion of nutritive fauna for fish [17]. Aside from being part of the pond food web, aquatic insects are considered useful as indicators of the impact of such environmental changes [18]. However, other species may serve as vectors of virulent pathogens with high transmission probability to fish and other aquatic animals [19]. Also, many predatory aquatic insects directly prey upon spawn, fry and fingerlings of fish [7].

As revealed in this study, tilapia ponds in this part of the Mt. Arayat cater only a small number of aquatic insects. Previous studies made during wet and dry seasons in tropical ponds showed higher insect richness [20, 21]. Low number of species and abundance observed in this study can be attributed to the practices and management of the farmers. Most of the established stations are practicing semi-intensive culture in which the stocks are partly dependent on the natural food, including insects present in the ponds. It was reported that fishes can reduce the emergence of aquatic insects up to 80% and this could directly affect abundance in adjacent terrestrial ecosystems [12]. In the study of Vidotto-Magnoni and Carvalho [5], aquatic insects appeared as the dominant food category in neotropical reservoirs.

In this study, most of the identified insect species are members of Coleoptera, Hemiptera and Odonata. The coleopterans or beetles are one of the most widely studied groups in the Philippines. However, there is still lacking information on how diverse this group is in artificial pond systems. It was estimated that about 850 species of aquatic and riparian beetles are occurring in the Philippines. However, only 317 species and subspecies were documented so far and 63% of these are endemic in the country [22]. The Hemipterans or water bugs also constitute a large part of the insect communities. This order exhibit enormous range of adaptive strategies compared to other insect orders [23]. According to Pellingen *et al*. [14], more than 200 species are known from the country of which Nepomorpha and Gerromorpha are dominant. Freitag and Zettel [23] also stated that these aquatic bugs are widely known in the country due to the hige number of taxonomic studies that have been carried out in the past decades. Insects belonging to this group are considered occasional pests in nursery ponds [1]. Meanwhile, the Odonatans or dragonflies and damselflies are commonly found in forested tropical regions [24]. The life of Odonatans greatly depends on water for food and reproduction. In comparison to previous studies, the number of species found in this study was very low. Studies reported 49 species of Odonatans in Surigao del Sur [25] and 36 species in Zamboanga del Sur [26]. However, these studies did not separate those found in different aquatic systems. The increase in the abundance of Odonatans in the dry season may suggest their recruitment to the pond units. It was claimed by Kashyap *et al*. [7] that abundance of Coleopterans, Hemipterans and Odonatans are detrimental to pond culture. This could be due to their predatory nature. The caretakers of the tilapia ponds also claimed that some of the insects are preying on their fingerlings.

Table 1: List of identified aquatic insects with their occurrence and mean frequency

Order	Species	Occurrence	
		Wet Season	Dry Season
Coleoptera	*Coelostoma* sp.	√	√
	Cybister tripunctatus	√	√
	Esolus sp.	√	√
	Hydroglyphus sp.	√	√
	Hydrophilus sp.	√	√
	Leiodytes sp.	√	x
	Thermonectus sp.	√	√
Diptera	*Polypedilum* sp.	√	√
	Tanypus sp.	√	x
Ephemeroptera	*Ephemera* sp.	√	√
	Cloeon sp.	√	√
	Ephemerella sp.	√	√
Hemiptera	*Anisops* sp.	√	√
	Appasus sp.	√	√
	Aquarius sp.	√	√
	Diplonychus sp.	√	√
	Paraplea sp.	√	√
	Ranatra gracilis	√	√
	Ranatra linearis	√	√
Lepidoptera	*Nymphula sp.*	√	√
Odonata	*Acisoma sp.*	√	√
	Diplacodes trivialis	√	√
	Ischnura sp.	√	√
	Othethrum sp.	√	√
	Pantala flavescens	√	√
	Rhinocypa sp.	√	√
	Trithemis sp.	√	√
Trichoptera	*Ecnomus* sp.	√	√

Legend: √ - present; x – absent

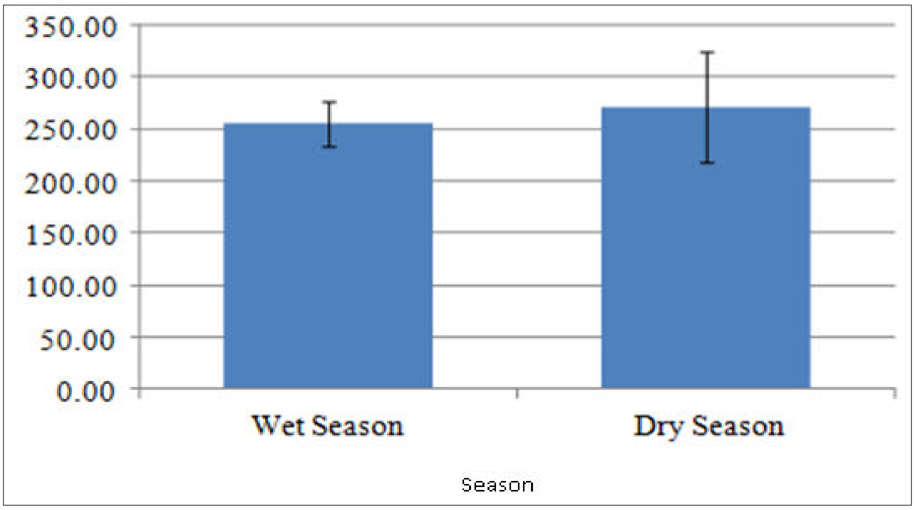


Fig 1: Mean overall abundance of aquatic insects in wet and dry seasons

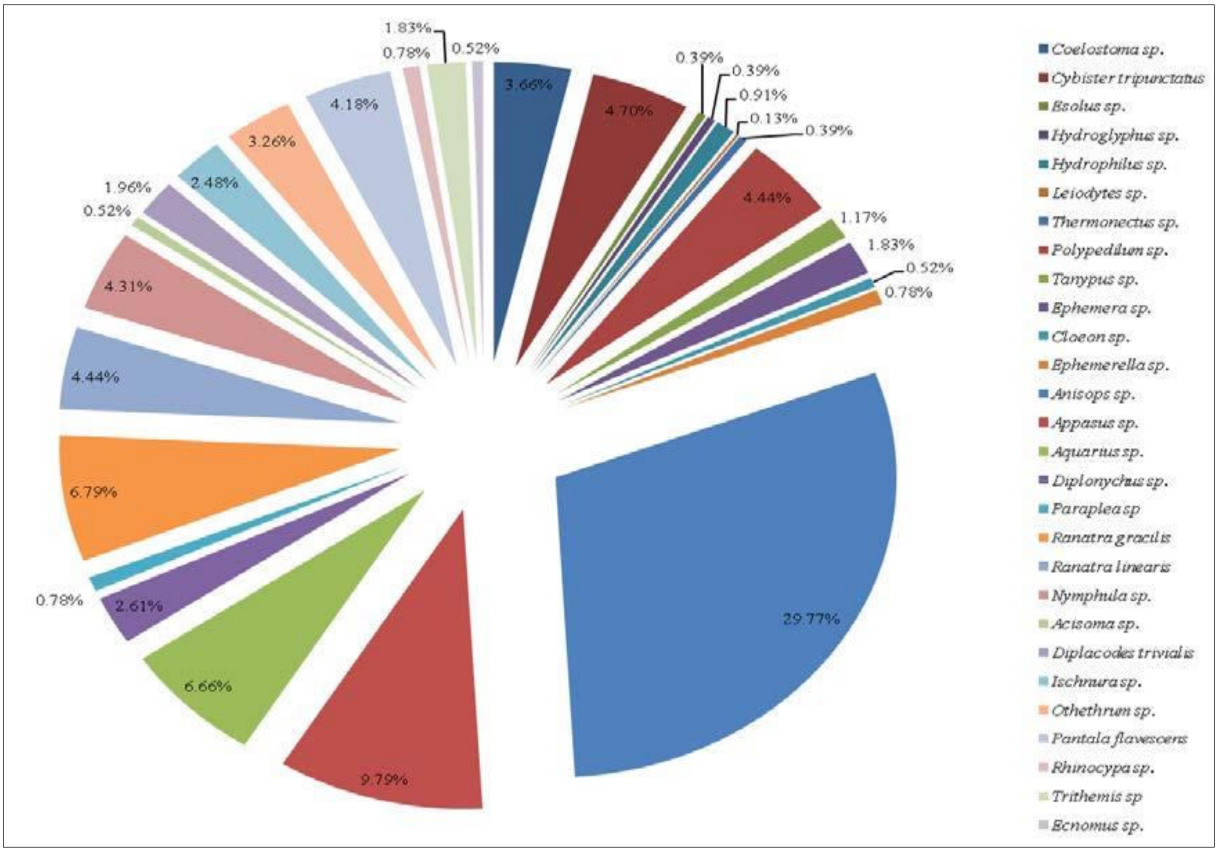


Fig 2: Relative abundance of aquatic insects during wet season

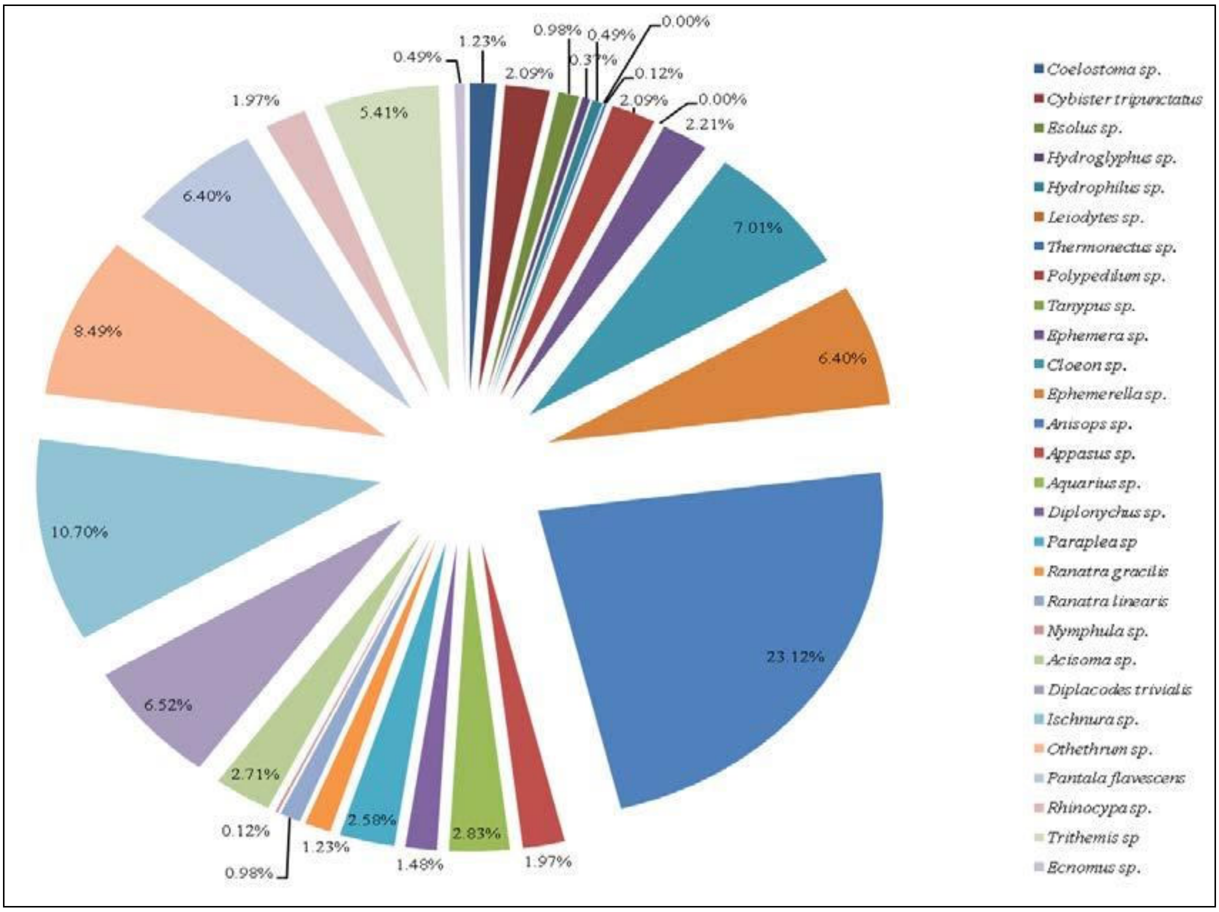


Fig 3: Relative Abundance of aquatic insects during dry season

Species Diversity and Similarity

The diversity of aquatic insects in the tilapia ponds was expressed using the diversity indices such as species richness, Shannon-Weiner diversity index, evenness index and simple community dominance (Table 2). Higher species richness was observed in the wet season (10.12). However, higher H' value was obtained in the dry season. Similar result was obtained for J'. Meanwhile, community dominance (CD) was observed higher in the wet season. In terms of species similarity (Table 3), it shows that there is high level of similarity between seasons (QS =0.956). It was observed that there is minimal difference on the diversity indices between seasons. However, obtained values indicated higher diversity during dry season. This is in contrast with the previous study conducted in the fishponds of southern Ivory Coast [20]. Meanwhile, the obtained values of H' are higher compared to the findings in the two water bodies of Chittagong University [27] but comparable with the recent study in a freshwater pond located in Benin [21]. From a statistical viewpoint, commonly observed H' values are between 1.5 to 3.5 in most ecological studies, with value increasing as both richness and evenness index increases [28]. Thus, it can be said that there is low species diversity in the tilapia ponds covered in this study. Although not studied, the feeding effect of tilapia could be an important factor influencing diversity. The result in the evenness index also indicates unequal settlements of individuals between seasons. This result can be supported by the obtained values for community dominance suggesting that the insect community in both seasons is dominated singly by *Anisops* sp. This result may imply the suitability of the pond ecosystems for *Anisops* sp. Also, this species may not be one of the natural food preferences of tilapia. In terms of community similarity, the result showed a very high similarity in between seasons. This may suggest that the identified aquatic insects are common dwellers in the study site regardless of season.

Table 2: Diversity indices of aquatic insects during wet and dry seasons

Diversity Index	Wet Season	Dry Season
SR	10.12	9.76
H'	1.11	1.17
J'	0.79	0.84
CD (%)	39.55	35.71

Table 3: Similarity quotient of aquatic insect communities during wet and dry seasons

	Wet Season	Dry Season
Wet Season		0.956
Dry Season		

Water Quality

The mean level of some water quality variables monitored in this study is presented in Table 4. Based from the result, there is only a minimal difference between seasons in relation to these variables. However, it can be seen that there is an increase in the level of temperature and dissolved oxygen and a decrease in pH and TDS in the dry season.

The level of water quality parameters (temperature, DO, pH and TDS) is similar to the report of Amita and Singh [29] in Bekarbanhtalab, India. The positive correlation of temperature, dissolved oxygen and pH to the number of species and abundance indicates the positive function of these parameters to the biodiversity of pond ecosystems in the North-western slope of Mt. Arayat. This result is in agreement with the findings of previous studies conducted in Ivory Coast [30, 20]. Meanwhile, the negative correlation of total dissolved solids to the number of species and overall abundance may infer the negative effect of the parameter. It was observed that the higher the TDS, there is a corresponding decline in the number of species and abundance. Budin *et al.* [31] also revealed a moderate to strong negative correlation between present solids to the abundance of the orders Epherometera, Pleocoptera and Trichoptera. The breathing organ of the insects can be easily clogged with suspended solids especially when in high concentration. Highest TDS was observed during the wet season and this can be attributed to the effect of rainfall and run-off that carries dissolved substances directly to the pond units.

Table 4: Level of some water quality variables during wet and dry seasons

Variable	Wet Season	Dry Season
Temperature (°C)	25.21	26.41
DO (ppm)	4.59	4.62
pH	6.64	6.66
TDS (ppm)	362.02	343.59

Correlation between water quality variables and Number of Species

The relationship of important water quality variables such as temperature, DO, pH and TDS to the number of species and abundance during wet season is indicated in Table 5. It can be gleaned that temperature, DO and pH have positive relationships with the number of species. However, TDS showed negative correlation with number of species.

Table 5: Correlation of water quality variables to the number of species and overall abundance during wet season

Variable	Correlation Coefficient	Variable	
		Number of Species	Overall abundance
Temperature	*r*	0.873	0.690
DO	*r*	0.810	0.593
pH	*r*	0.840	0.743
TDS	*r*	-0.910	-0.457

Correlation between water quality variables and Overall abundance

As shown in Table 6, similar result has also obtained in the relationship of temperature, DO, pH and TDS with number of species and overall abundance. Temperature, DO and pH are positively correlated with number of species and overall abundance while TDS showed negative relationship with these variables.

Table 6: Correlation of water quality variables to the number of species and overall abundance during dry season

Variable	Correlation Coefficient	Variable	
		Number of Species	Overall abundance
Temperature	*r*	0.623	0.737
DO	*r*	0.850	0.513
pH	*r*	0.713	0.583
TDS	*r*	-0.603	-0.760

The insignificant variations observed in the number of species, abundance and diversity values and strong similarity of insects among sampling sites in both seasons may indicate the effect of minimal seasonal variations on level of measured water quality variables. The same observation has been reported in manmade fishponds [32, 33].

Conclusion

The study identified 28 species of aquatic insects belonging to 7 orders in the selected tilapia ponds located in the North-western slope of Mt. Arayat. However, the result suggests that diversity is low and there are unequal distributions due to high dominance of *Anisops* sp. Further, species identified are almost similar between seasons of which may imply weak seasonal effect. Meanwhile, variation observed on the abundance and diversity of aquatic insects between seasons could be a function of such changes in water quality. The increase in the TDS level of pond systems has a negative effect on the number of species and abundance of aquatic insects. However, further study is indispensable particularly on the feeding effect of tilapia stocks that could significantly affect insect diversity during production period. Analysis of gut content is recommended to be done in order to supplement why such species are abundant or sparse.

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