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Original Article

Distribution and diversity of aquatic insects in different water bodies of Qatar

Distribuição e diversidade de insetos aquáticos em diferentes corpos de água do Catar

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Abstract

Aquatic insect fauna remains an important tool for bio indication of environmental disturbance, while maintaining a healthy aquatic system. The purpose of the study was to document and to identify the diversity and distribution patterns of aquatic insect, a highly ignored aspect from the Qatar. Following the standard procedures, the samples were collected from aquatic habitats during the period October 2015 to May 2017 on monthly basis. A total of 11,287 individuals, belonging to 6 orders were captured. Dipterans were the abundant with the percentages of 71.01 (n=8,015), while the lowest percentage was observed for Coleoptera 0.04 (n=05). Twelve insects families were identified, among these five were reported under Diptera, followed by Hemiptera (03), while Coleoptera, Tricoptera, Odonata, and Ephemeroptera were represented by single families. Among the selected localities, Dipterans were collected from 10 stations, followed by Hemiptera (9), Coleoptera (4), Odonota (4), Ephemeroptera (3) and Trichoptera (1) respectively. Among the water bodies samples, streams were the most preferred habitats (n=2,767), while drinking water pools were the least (27). Moreover, the highest Simpson diversity index of 1.48 and lowest of 0.47 was recorded for flooded sewage pool and plastic containers respectively, while the low evenness values were observed for ponds, and less than 1 Margalef's diversity values were seen for all habitats. This study documents the patterns of the diversity and distribution of aquatic insects, and provides a baseline for the future studies from Qatar.

Keywords: entomofauna, biodiversity, distribution, Qatar, water bodies.

Resumo

A fauna aquática de insetos continua sendo uma ferramenta importante para a bioindicação de distúrbios ambientais, ao mesmo tempo em que mantém um sistema aquático saudável. O objetivo do estudo foi documentar e identificar a diversidade e os padrões de distribuição dos insetos aquáticos, um aspecto altamente ignorado no Catar. Seguindo os procedimentos padrão, as amostras foram coletadas em hábitats aquáticos durante o período de outubro de 2015 a maio de 2017, mensalmente. Um total de 11.287 indivíduos, pertencentes a seis ordens, foram capturados. Dípteros foram os mais abundantes, com as porcentagens de 71,01 (n = 8.015), enquanto a menor porcentagem foi observada para Coleópteros 0,04 (n = 05). Doze famílias de insetos foram identificadas, destas, cinco foram registradas sob Diptera, seguido por Hemiptera (03), enquanto Coleoptera, Tricoptera, Odonata e Ephemeroptera foram representados por famílias únicas. Dentre as localidades selecionadas, Dipterans foram coletados em 10 estações, seguidos por Hemiptera (9), Coleoptera (4), Odonota (4), Ephemeroptera (3) e Trichoptera (1), respectivamente. Entre as amostras de corpos d'água, os riachos foram os hábitats mais preferidos (n = 2.767), enquanto as piscinas de água potável foram os menos (27). Além disso, o maior índice de diversidade de Simpson de 1,48 e o menor de 0,47 foi registrado para piscina de esgoto inundada e recipientes de plástico, respectivamente, enquanto os valores de baixa uniformidade foram observados para lagoas e menos de 1 valores de diversidade de Margalef foram observados para todos os hábitats. Este estudo documenta os padrões de diversidade e distribuição de insetos aquáticos e fornece uma linha de base para os estudos futuros do Catar.

Palavras-chave: entomofauna, biodiversidade, distribuição, Catar, corpos d'água.

1. Introduction

Biodiversity is often extremely underestimated by societies and the organizations, which are the responsible for the conservation of biodiversity (Dietz and Adger, 2003). Rapid population growth, economic development, urbanization, industrialization and environmental concerns of water stress, has emerged as a real threat for aquatic

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insects in Qatar. Enormous activities of constructions, have resulted in the disappearing of many coastal and inland habitats (Richer, 2008), which consequence in the decline of biodiversity of aquatic insect. These insects serve as a food for amphibians and have a critical role in the stability of ecosystem (Hershey et al., 2010), and are the indicators of the water quality (Barros, 2001). The use of aquatic insect to assess the quality of water provides necessary information to take actions regarding environment management (Hossain et al., 2015). Anthropogenic activities, especially climate change and urbanization are the continues threat for the aquatic ecosystem, that effects the insect diversity (Lundquist and Zhu, 2018).

Aquatic insects can be found in almost every type of aquatic habitat throughout the world counting lakes, heavy streams, seaside water, saline pool, groundwater, and even pools of unrefined petroleum leaking (Chainey, 2004). Though the total makeup of aquatic insects is between 3 to 5%, among all insect species (Abhijna et al., 2013), but their role is critical, as they serve as an indicator for the human impact, on aquatic ecosystem. Moreover, Aquatic insects are especially appropriate for use of environmental impact assessment and has long convention in checking the water quality, and provide a range of responses to disturbance influences at several levels by organisms (Bonada et al., 2006). Ephemeroptera, Plecoptera and Tricoptera are the most sensitive to the natural disturbance, anthropogenic influences and to pollution, and are considered as an important component of accumulations of aquatic insects (Cíbik et al., 2021).

In the past few decades, expansion of urbanization in Qatar has affected the insect fauna, particularly mosquitoes and other aquatic insects. Development in rapid transport system, tourism, trade links, and human-environmental changes are expected to affect the species composition in Qatar. In the most parts of the State with favorable climatic conditions, development has led to the creation of more permanent as well as temporary breeding sites for mosquitoes (Alkhayat et al., 2020). Although aquatic insects have been thoroughly investigated in the region (Shekha, 2011; Gattolliat et al., 2012; Abd El-Wakeil and Al-Thomali, 2013; Hanna and Shekha, 2015). However, knowledge of freshwater fauna in Qatar is extremely limited, and there is no detailed study on aquatic insects, hence, the main objective of this study is to report the diversity and distribution of insects, thriving the aquatic habitats of Qatar.

2. Materials and Methods

2.1. Study area

Qatar is located in Western Asia, a peninsula extending from the Arabian Desert as an outcrop in the western Arabian Gulf, and lies between longitude 50°45′ and 51°40′ E and latitude 24°27′ and 26°10′ N . Qatar is an arid or semi-arid country and is among the warmest regions of the world, with mild winter. Summer is the longest season extending from May to September; fall is the shortest season from October to November, winter is from December to February and spring from March to April. During summer, temperature reaches up to 50 °C, while fall and the winter seasons remains moderate (Batanouny, 1981; Yasseen and Al-Thani, 2013). Moreover, relative humidity usually reaches 100% throughout the year, but it can get as low as 5% and 28% during July and December, respectively (Abulfatih et al., 2001). Qatar receives low and an irregular rainfall, and during the last 20 years (1990-2008) the country has received almost 92 mm/ year, with the high rate of evaporation (Darwish and Mohtar, 2013). Samples were collected from the 14 stations of Qatar namely: Alkhor, Rawadat Alfaras, Alkaraana, Hazm Almarkhiya, Alwakra, Nuaija, Doha, Alrayyan, Aldafna, Alkhiesa, Umm Salal, Alshahaniya, Industrial Area and Mesaieed. These localities represent land use; urban, agriculture, livestock, natural and industrial area, and the characteristic of these selected localities are given in Table 1.

2.2. Sampling and identification

The samples were collected from the aquatic bodies between October 2015 to May 2017 on monthly basis. The samples (larvae, pupae, nymphs, and adults) were collected from relatively small water bodies by standard dipper, and from large water body by plankton nets and D-frame aquatic kick net. In general, 3, 5 and 10 scoops were taken at each breeding site depending on the habitat size. The insects were sorted and screened by placing in the white trays. Content of each aquatic site was shifted in plastic containers (500 ml) with some of water from the same habitat. Containers were labelled with the all necessary information, placed in an ice-container and transported to the laboratory for sorting, counting and identification. The insects were sorted into the main taxonomic groups, and identification of some samples was done up to the family or subfamily levels and some members are identified up to genera level through appropriate taxonomic keys (Winterbourn and Gregson, 1981; Morse et al., 1994; Cummins and Merritt, 1996; Epler, 2001).

2.3. Data analysis

Descriptive analysis was done by using Excel version 2013 software. The mean number of aquatic insects was calculated per dip for each breeding habitat by dividing the total number of individuals of aquatic insects collected at such breeding habitat (n) over the total number of dips (N), where Mean= n/N. The relative abundance of aquatic insect orders for the investigated aquatic bodies was calculated. PAST version 3 was used to calculate the species diversity for the ten aquatic habitats; taxa (S), abundance, dominance (D), Simpson (1_D), Shannon-Weiner index (H), richness, evenness and Margalef's diversity index (d) (Tawfik et al., 2013).

3. Results

3.1. Composition of aquatic insects

A total of 11,287 aquatic insect larvae, nymphs and adults were collected, and were identified under 6 orders.

Table 1. Characteristic of study sites selected for the collection.

Station name (no.)	Latitude "N"	Longitude "E"	Elevation (m)	Nature of sampling area	Aquatic body sampled
Alkhor (St.1)	25°42'50.60" 25°42'19.60"	51°32'56.97" 51°33'13.66"	5.8 2.4	Coastal area	Treated sewage swamp and stream
Rawdat Alfaras (St.2)	25°42'37.13"	51°21'51.94"	18.3	Agriculture farm	Metal containers, flooded sewage pool, and irrigation water pools
Alkaraana (St.3)	24°58'54.11"	51°021'8.88"	52.4	lagoon	Treated sewage swamp
Hazm Almarkhiya (St.4)	25°20'33.23"	51°28'59.79"	18.9	Urban "household"	House fountain
Alwakra (St.5)	25°03'43.77"	51°32'45.94"	2.44	Livestock farm	Plastic containers
Nuaija (St.6)	25°145'6.34"	51°31'50.34"	9.14	Urban "Marshy inland and household"	Rising watertable pools, plastic containers, and ponds
Doha (St.7)	25°17'29.80"	51°314'683"	12.8	Urban "Roads and workers household"	drainage, drinking water pools, flooded sewage pools, and tyres
Alrayyan (St.8)	25°12'11.04"	51°26'04.01"	21.9	Urban "Roads & household"	House fountains, drinking water pools, flooded sewage, and risen watertable
Aldafna (St.9)	25°21'35.18"	51°29'56.00"	5.8	Urban "Roads, household and Qatar University campus"	drinking water pools, fountains, metal containers, and a stream
Alkhiesa (St.19)	25°23'53.93"	51°27'06.91"	14.3	Urban "household"	House fountain
Umm Salal (St.11)	25°27'49.14"	51°20'52.88"	17.7	Agriculture farms	Irrigation water pools
Alshahaniya (St.12)	25°24'32.16"	51°11'08.63"	43.9	Livestock farm	Metal containers
Industrial area (St.13)	25°09'23.03"	51°23'18.54"	34.4	Roads and worker house"	drinking water pools and flooded sewage pools
Mesaieed (St.14)	24°58'16.07"	51°33'15.59"	3.048	Marshal land	Rising watertable pools

Dipterans were the highest 71.01% (n= 8,015) followed by Hemiptera 26.01% (n= 2,936), Odonata 2% (n= 226), Ephemeroptera 0.86% (n= 97), Trichoptera 0.07% (n= 8), and Coleoptera 0.04% (n= 5) (Figure 1).

Five genera of the order Diptera were identified belonging to three families. The family Chironomidae represented two subfamilies, namely; Chironominae (two genera: *Chironomus* and *Polypedilum*) and Orthocladinae (one genus: *Cricotopus*). Ephydridae was represented by one subfamily; Ephydrinae (one genus: *Ephydra*). Syrphidae was represented by one subfamily; Eristalinae (one genus: *Eristalis*). Some individuals of the two families; Psychodiade and Tabanidae were also collected. Three Hemipterans families were identified, namely; Corixidae (one genus: *Sigara*), Notonectidae (one genus: *Anisops*), and Veliidae

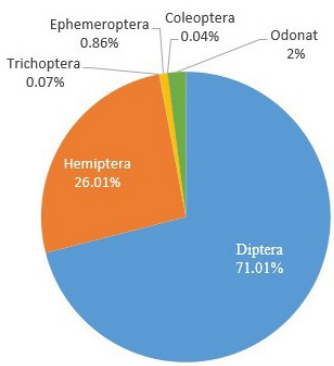

Figure 1. Composition of aquatic insects representing six orders collected in Qatar.

(one genus: *Microvelia*). Odonata was represented by one family, namely Libelullidae (one genus: *Orthetrum sabina*). Furthermore, 4 orders of the collected aquatic insects were identified to family levels; Coleoptera (one family; Dytiscidae), Ephemeroptera (one family; Baetidae), and Trichoptera (one family; Philopotamidae) (Table 2).

3.2. Species richness and diversity

Biodiversity indices were estimated for Diptera, Hemiptera and Odonata, which were identified to generic level. Order Diptera (68.64%) showed higher species richness, followed by Hemiptera (29.12%), and Odonata (2.24%). However, the abundance of different insect groups showed that Diptera dominated the collections (71.01%), followed by Hemiptera (26.01%), while the lowest abundance was observed for Coleoptera (0.04%) (Table 3).

Five families were identified under the order Diptera, the most common was Chironomidae with the percentage of 56.97 (n= 4,566), followed by Ephydridae 28.12% (n= 2,254), Psychodidae 13.54% (n= 1,085), Syrphidae 1.25% (n= 100) and Tabanidae 0.12% (n= 10). Hemiptera represented the three families, abundant was Notonectidae with the higher percentage of 41 (n= 1,201), Corixidae 39% (n= 1,141) and Veliidae at 20% (n= 594). While, Odonata, Ephemeroptera, Trricoptera and Coleoptera were represented by single families Libelullidae (n= 226), Baetidae (n= 97), Philopotamidae (n= 8) and Dytiscidae (n= 5) respectively (Table 3).

Table 2. Taxa of aquatic insects collected from twelve stations in Qatar.

Order	Family	Subfamily	Genus
Diptera	Chironomidae	Chironominae	*Chironomus*
			Polypedilum
		Orthocladinae	*Cricotopus*
	Ephydridae	Ephydrinae	*Ephydra*
	Phsychodidae		unidentified
	Syrphidae	Eristalinae	*Eristalis*
	Tabanidae		unidentified
Hemiptera	Corixidae		*Sigara*
	Notonectidae		*Anisops*
	Veliidae		*Microvelia*
Coleoptera	Dytiscidae		unidentified
Trichoptera	Philopotamidae		unidentified
Odonata	Libelullidae		*Orthetrum sabina*
Ephemeroptera	Baetidae		unidentified

Table 3. Families distribution of aquatic insects showing number and frequency of individuals.

Order	Family	No. of genus	%	Individuals	Total	Frequency
Diptera	Chironomidae	3	37.5	4,566	8,015	71.01%
	Ephydridae	1	12.5	2,254		
	Psychodidae			1,085		
	Syrphidae	1	12.5	100		
	Tabanidae			10		
Hemiptera	Corixidae	1	12.5	1,141	2,936	26.01%
	Notonectidae	1	12.5	1,201		
	Veliidae	1	12.5	594		
Coleoptera	Dytiscidae			5	5	0.04%
Trichoptera	Philopotamidae			8	8	0.07%
Odonata	Libelullidae	1		226	226	2%
Ephemeroptera	Baetidae			97	97	0.86
Total		9		11,287		

3.3. Geographical distribution of aquatic insects

Dipterans were collected from 10 stations, followed by Hemiptera (9 stations), Coleoptera and Odonata (4 stations), Ephemeroptera (3 stations) and Trichoptera in 1 station. The highest number of individuals (3,410) insects were recorded in Nuaija aquatic bodies, and a minimum of 46 were captured in the Umm Salal (Table 4).

Among the aquatic insects collected, Chironomidae was collected from eight stations; *Chironomus* sp. was found in eight stations and it was the most abundant in Nuaija at 52.5% (n= 1,848), followed by Alkaraana at 13.5% (n= 474), Alkhor at 9.7% (n= 341), Alwakra at 11.4% (n= 401), Alrayyan at 7.44% (n= 262), Hazm Almarkhiya at 3.5% (n= 123), Rawdat Alfaras at 1.65% (n= 58), and Alshahaniya at 0.31% (n= 11). *Polypedilum* sp. was recorded from two stations, Alkaraana at 61.9% (n= 140), and Alkhor at 38.1% (n=86). *Cricotopus* sp. was recorded from seven stations, Aldafna at 58.15% (n= 478), Nuaija at 30.4% (n= 250), Alrayyan at 4.14% (n= 34), Alkhor at 3.3% (n= 27), Hazm Almarkhiya at 1.58% (n= 13), Alwakra at 1.34% (n= 11), and Rawdat Alfaras at 1.09% (n= 9). Ephydridae was represented by *Ephydra* sp and was mostly encountered at Nuaija 49.9% (n= 1,126), followed by Alkhor at 42.2% (n= 952), Alrayyan at 5.68% (n= 128), Alkaraana at 0.97% (n= 22), Doha and Industrial Area showed similar abundance of 0.44% (n= 10), and low abundance in Aldafna at 0.27% (n= 6). *Eristalis* sp of the family Syrphidae was mostly found in Rawdat Alfaras at 52% (n= 52), followed by Alrayyan at 23% (n=23), Umm Salal at 14% (n= 14), and Doha at 11% (n= 11) (Table 5).

Table 4. Composition and geographical distribution of aquatic insects in ten stations from the selected localities.

Station		Individuals numbers and frequency						Total
No.	Name	Diptera	Trichoptera	Hemiptera	Odonata	Ephemeroptera	Coleoptera	
St.1	Alkhor	1,923 (23.99)	0	659 (22.4)	97 (42.9)	16 (16)	0	2,695
St.2	Rawdat Alfaras	177 (2.21)	0	16 (0.5)	0	0	1 (20)	194
St.3	Alkaraana	636 (7.94)	8 (100)	1,559 (53.1)	2 (0.9)	0	0	2,205
St.4	Hazm Almarkhiya	205 (2.56)	0	413 (14.1)	67 (29.64)	44 (45)	1 (20)	730
St.5	Alwakra	412 (5.14)	0	0	0	0	1 (20)	413
St.6	Nuaija	3,251 (40.56)	0	60 (2)	60 (26.54)	37 (38)	2 (40)	3,41
St.7	Doha	363 (4.53)	0	0	0	0	0	363
St.8	Alrayyan	457 (5.7)	0	0	0	0	0	457
St.9	Aldafna	556 (6.94)	0	17 (0.6)	0	0	0	573
St.11	Umm Salal	24 (0.3)	0	22 (0.7)	0	0	0	46
St.12	Alshahaniya	11 (0.14)	0	123 (4.2)	0	0	0	134
St.13	Industrial Area	0	0	67 (2.3)	0	0	0	67
Total		8,015	8	2,936	226	97	5	11,287

Table 5. Composition and geographical distribution of nine genera of Qatar.

	Chironomus	*Polypedilum*	*Cricotopus*	*Ephydra*	*Eristalis*	*Sigara*	*Anisops*	*Microvelia*	*Orthetrum sabina*
St.1	341 (9.7)	86 (38.1)	27 (3.3)	952 (42.2)	0	566 (49.6)	0	93 (15.65)	97 (42.9)
St.2	58 (1.65)	0	9 (1.09)	0	52 (52)	0	0	0	0
St.3	474 (13.5)	140 (61.9)	0	22 (0.97)	0	503 (44.1)	1,054 (87.8)	2 (0.33)	2 (0.9)
St.4	123 (3.5)	0	13 (1.58)	0	0	0	0	413 (69.53)	67 (29.64)
St.5	401 (11.4)	0	11 (1.34)	0	0	0	0	0	0
St.6	1,848 (52.5)	0	250 (30.4)	1,126 (49.9)	0	0	0	60 (10.1)	60 (26.54)
St.7	0	0	0	10 (0.44)	11 (11)	0	0	0	0
St.8	262 (7.44)	0	34 (4.14)	128 (5.68)	23 (23)	0	0	0	0
St.9	0	0	478 (58.15)	6 (0.27)	0	0	7 (0.6)	10 (1.68)	0
St.11	0	0	0	10 (0.44)	14 (14)	22 (1.9)	0	0	0
St.12	11 (0.31)	0	0	0	0	50 (4.4)	73 (6.1)	16 (2.69)	0
St.13	0	0	0	0	0	0	67 (5.6)	0	0
Total	3,518	226	822	2,254	100	1,141	1,201	594	226

A single species was identified under Corixidae family; *Sigara* sp. the majority was found at Alkhor 49.6% (n=566), followed by Alkaraana at 44.1% (n=503), Alshahaniya at 4.4% (n=50) and Umm Salal at 1.9% (n=22). Notonectidae was represented by one genus, *Anisops* sp., which was highly abundant in Alkaraana with the percentage of 87.7 (n=1,054), followed by Alshahaniya 6.1% (n=73), Industrial Area 5.6% (n= 67) and Aldafna at 0.6% (n=7). Veliidae accounted for one species, *Microvelia* sp, and was mostly found at Hazm Almarkhiya 69.53% (n= 413), followed by Alkhor at 15.65% (n= 93), Nuaija at 10.1% (n= 60), Alshahaniya at 2.69% (n= 16), Aldafna at 1.68% (n= 10), and Alkaraana at 0.33% (n= 2). Odonata was represented by one species; *Orthetrum sabina*, the majority of specimens were collected from Alkhor at 42% (n= 97), followed by Hazm Almarkhiya at 29.6% (n= 67), Nuaija at 26.5% (n= 60), and Alkaraana at 0.9% (n= 02). (Table 5).

3.4. Abundance of aquatic insects in water bodies

Table 6 shows the abundance of aquatic insects in Qatar with their percentage frequencies during the period of investigation. Streams were the most abundant habitat (n= 2,767), while drinking water pool was the least abundant (n= 27). Diptera was mostly abundant in plastic containers (n= 2,516, 31.4%), and least in irrigation water pool (n= 24, 0.29%). Hemiptera was mostly found in swamps (n= 1,559, 53.09%), and in low abundance in plastic containers (n= 60, 2.04%). Coleoptera was encountered in three aquatic habitats; plastic container (n=3, 60%), metal container (n= 1, 20%), and fountain (n= 1, 20%). Odonata was encountered in four habitats; streams (n= 97, 42.9%), fountains (n= 67, 29.6%), ponds (n= 60, 26.5%), and treated sewage swamp (n= 2, 0.9%). Ephemeroptera was found in fountains (n= 44, 45%), ponds (n= 37, 38%), and streams (n= 16, 16%). Trichoptera was found in only one habitat; treated sewage water (n= 8, 100%). Among the six order of aquatic insects, Diptera had the highest relative abundance (71.01%), while Coleoptera showed the lowest relative abundance (0.04%).

The abundance of genera of aquatic insects in Qatar with their percentages of frequency during the period of investigation is shown in Table 7. The only species found in drainage water was *Eristalis* larvae (n= 23). In drinking water pools two species were found, *Ephydra* sp. (n=16, 59%), and *Eristalis* sp. (n= 11, 41%). Five different larvae were encountered in flooded sewage pools, and the most abundant was *Chironomus* sp. (n= 133, 32%) and *Ephydra* sp. (n= 128, 31%). *Cricotopus* larvae (n= 491, 41%), were the most abundant in fountains. In irrigation water pools, *Sigara* sp. (n= 72, 75%) was the most abundant. *Anisops* sp. (n= 73, 48%), was found abundant in metallic containers, while in plastic containers *Chironomus* sp (n= 2,160, 86%) was the most dominant. *Ephydra* larvae were most abundant in ponds, (n= 1,048, 88%), and streams (n= 952, 46%). While, treated sewage swamps were dominated by *Anisops* insects (n= 1,054, 48%), followed by Sigara sp. (n= 503, 23%).

Table 8 shows the diversity, taxa richness and dominance indices of specimens collected during the study period. Simpson index of biodiversity (1-D) was highest in flooded sewage pools (0.75), and was least in drainage water (0). The highest Shannon diversity index of 1.48 and 1.46 was noted in flooded sewage pool and streams, while the lowest values were recorded for plastic containers (0.47) and ponds (0.62). Low evenness values were recorded from ponds (0.46) and highest were from drains (1). While, Margalef diversity index for all water bodies investigated was less than 1, where streams and treated sewage swamps had the highest richness (Taxa= 7).

Table 6. The overall composition and abundance of aquatic insects encountered during sampling of ten aquatic habitats in Qatar.

Order	Number of individuals										Total	RA%
	D	DWP	FSP	F	IWP	MC	PC	P	S	TSS		
Diptera	249 (3.1)	27 (0.34)	473 (5.9)	827 (10.3) bn	24 (0.29)	121 (1.5)	2516 (31.4)	1147 (14.3)	1995 (24.9)	636 (7.93)	8015	71.01
Hemiptera	0	0	67 (2.28)	430 (14.64)	72 (2.45)	89 (3.03)	0	60 (2.04)	659 (22.44)	1559 (53.09)	2936	26.01
Coleoptera	0	0	0	1 -20	0	1 (20)	3 -30	0	0	0	5	0.04
Trichoptera	0	0	0	0	0	0	0	0	0	8 -100	8	0.07
Odonata	0	0	0	67 (29.6)	0	0	0	60 (26.5)	97 (42.9)	2 (09.)	226	2.0
Ephemeroptera	0	0	0	44 -45	0	0	0	37 (38)	16 -16	0	97	0.86
Total	249	27	540	1,369	96	211	2519	1,304	2,767	2,205	11,287	

Key: D = drainage; DWP = drinking water pool; FSP = flooded sewage pool; F = fountain; IWP = irrigation water pool; MC = metal container; PC = plastic container; P = pond; S = stream; TSS = treated sewage swamp; RA = relative abundance. Table 7. Distribution of genus of aquatic insects at 10 different aquatic bodies in Qatar.

Table 7. Distribution of genus of aquatic insects at 10 different aquatic bodies in Qatar.

Habitat	*Chironomus*	*Polypedilum*	*Cricotopus*	*Ephydra*	*Eristalis*	*Sigara*	*Anisops*	*Microviliia*	*Orthetrum sabina*	Total
D	0	0	0	0	23 (100%)	0	0	0	0	23
DWP	0	0	0	16 (59%)	11 (41%)	0	0	0	0	27
FSP	133 (32%)	0	34 (8%)	128 (31%)	52 (13%)	0	67 (16%)	0	0	414
F	267 (21.27%)	0	491 (39.12%)	0	0	0	7 (0.56%)	423 (33.7%)	67 (5.34)	1,255
IWP	0	0	0	10 (10%)	14 (15%)	72 (75%)	0	0	0	96
MC	54 (36%)	0	9 (6%)	0	0	0	73 (48%)	16 (10.5%)	0	152
PC	2,160 (86%)	0	261 (10%)	78 (3%)	0	0	0	0	0	2,499
P	89 (7.1%)	0	0	1,048 (83.37%)	0	0	0	60 (4.77%)	60 (4.77%)	1,257
S	341 (15.77%)	86 (3.97%)	27 (1.24%)	952 (44.03%)	0	566 (26.17%)	0	93 (4.3%)	97 (4.5%)	2,162
TSS	474 (21.5%)	140 (6%)	0	22 (1%)	0	503 (23.9%)	1,054 (47.9%)	2 (0.09%)	2 (0.09)	2,197

Key: D = drainage; DWP = drinking water pool; FSP = flooded sewage pool; F = fountain; IWP = irrigation water pool; MC = metal container; PC = plastic container; P = pond; S = stream; TSS = treated sewage swamp.

Table 8. Diversity and other indices of aquatic insects collected from different habitats of Qatar.

	Sampling habitats									
	D	DWP	FSP	F	IWP	MC	PC	P	S	TSS
No. of Taxa	1	2	5	5	3	4	3	4	7	7
No. of individuals	23	27	414	1255	96	152	2499	1257	2162	2197
Dominance_D	1	0.52	0.24	0.31	0.59	0.37	0.76	0.70	0.29	0.33
Simpson_1-D	0	0.48	0.75	0.68	0.41	0.63	0.24	0.29	0.70	0.66
Shannon_H	0	0.67	1.48	1.24	0.73	1.12	0.47	0.62	1.46	1.25
Evenness	1	0.98	0.88	0.69	0.69	0.76	0.53	0.46	0.61	0.50
Margalef	0	0.30	0.66	0.56	0.44	0.59	0.25	0.42	0.78	0.77

Key: D = drainage; DWP = drinking water pool; FSP = flooded sewage pool; F = fountain; IWP = irrigation water pool; MC = metal container; PC = plastic container; P = pond; S = stream; TSS = treated sewage swamp.

4. Discussion

The present study documents the patterns of the diversity and distribution of aquatic insects in different water dwellings of Qatar. The findings of the current study showed that the aquatic insect fauna of the Qatar is consisted of six orders namely; Diptera, Hemiptera, Trichoptera, Coleoptera, Odonata, and Ephemeroptera, and most of the insects were collected and identified for the first time in few numbers.

In the current findings Dipteran were the most abundant in all the habitats, and the family Chironomidae represented the three genera, the members of this order are considered as most diverse and the tolerant members of the aquatic habitat (Bouchard et al., 2004). Previous findings showed that the larvae of these genera were found in different habitats with presence of organic material and were predators of mosquito larvae (Shaalan and Canyon, 2009). The Chironomidae was the most abundant family, and it is considered as widely distributed because of its high tolerance towards pollution (Popoola and Otalekor, 2011; Abhijna et al., 2013; Çetinkaya and Bekleyen, 2017). Species of genus *Chironomus* are tolerant (Al-Shami et al., 2010; Sharma and Agrawal, 2012; Abdo et al., 2013), and had previously been recorded in Abu Nakhla and Alkhor wetlands in Qatar (Kardousha, 2016) while, *Polypedilum* and *Cricotopus* are reported for the first time during this study. Similarly, genus *Eristalis*, a tolerant species (Abdo et al., 2013) larvae under Syrphidae were identified for first time, and was mostly detected in flooded sewage swamps. However, the adults were previously recorded at Mesaieed and Doha, by Abdu and Shaumar (1985), similarly the *Ephydra* had been reported previously by Kardousha (2016).

The family Psychodidae and Tabanidae larvae were collected for the first time, and we were unable to identify up to next level. The majority of Psychodidae larvae were found in streams, while Tabanidae was found only in ponds. The members of family Psychodidae like *Psychoda*

spp cause urogenital myiasis, as a result of poor hygienic conditions and poor personal hygiene and is reported from Turkey (Taylan-Ozkan et al., 2004), and Egypt (Yones and Bakir, 2014). While the members of family Tabanidae cause nuisance to human and livestock, transmits several pathogens and resulted in reduction of milk yields in cattle (Baldacchino et al., 2014), and is poorly known in the Middle East with few records from Saudi Arabia (Al Dhafer et al., 2009).

The water boatman, *Sigara*, under the family Corixidae order Hemiptera was found most abundant in streams in Alkhor, accompanied by the backswimmer, *Anisops* from treated sewage swamps in Alkaraana. The water boatman *Sigara striata* was recoded in Alkhor by Abdu and Shaumar (1985), Dukhan (Abdu and Shaumar, 1985), and Bu Nakhla (Kardousha, 2016). Corixidae (*Micronecta* spp.) is considered as a predator of mosquito larvae (Ohba et al., 2011). While *Anisops* sp. was reported before in Bu Nakhla and Alkhor in Qatar by Kardousha (2016). This species is considered as a biocontrol agent against mosquito larvae *Culex quinquefasciatus* (Alahmed et al., 2009). While, the family Veliidae was represented by one genus, (*Microvelia*) encountered in different habitats, in high numbers from fountains in Hazm Almarkhiya and is reported for the first time. Generally, the members of Hemiptera are predators of several aquatic organisms, particularly the larvae of noxious insects such as mosquitoes, and midge flies (Sharma and Agrawal, 2012), whereas *Microvelia* spp. is found as a predator of *Aedes aegypti* larvae (Ohba et al., 2011).

In this study, the larvae of Dytiscidae under Coleoptera, in very low abundance were encountered in all manmade habitats like fountains, metal and plastic containers. The members of this family are predacious in nature (Majumder et al., 2013) particularly on larvae of *Culex quinquefasciatus* (Shaalan and Canyon, 2009), and were previously recorded from Alkhor at larval stage (Kardousha, 2016), and as adults in Alshahaniya (Abdu and Shaumar, 1985). Similarly, the samples of Tichoptera and Ephemeroptera were also observed in low numbers from one and three stations respectively. Both are intolerant to pollution (Abhijna et al., 2013; Majumder et al., 2013) and the family Baetidae (Ephermeropteran) is the new from Qatar, collected from fountains, ponds and streams in coastal area of Alkhor. The members of this Order (Mayfly larvae) are considered as a main source of food for certain type of larvivorous fish (Sharma and Agrawal, 2012).

The only species *Orthetrum sabina*, belonging to Odonata was recorded in high density in fountains and streams, with approximately same density in Hazm Almarkhiya and Nuaija. While this species was collected in low density from treated sewage swamps in Alkaraana. Previously, it was observed in Bu Nakhla and Alkhor (Kardousha, 2016), and in Rawdat Alfaras and Umm Salal as adult (Abdu and Shaumar (1985). The Diversity and abundance of Odonata indicates the health status of the water bodies (Sharma and Agrawal, 2012), and is also considered as an important predators of mosquito larvae in freshwater ecosystems (Shaalan and Canyon, 2009).

In the present study, different diversity indexes showed different trends. Highest Shannon index values were recorded for flooded sewage pool (1.48) and lowest was observed for drinking water pool (0.67), which actually indicates the poor diversity of insects. However, the diversity of insects in water bodies is favored by the nutrients and environmental conditions of the habitat (Abhijna et al., 2013). The Margalef's index values greater than 3 are indicator of clean conditions, values less than one (1) indicate heavy pollution, while values between one to three (1-3) indicate moderately polluted conditions (Lenat and Penrose, 1980). The findings of this study showed values less than 1 for Margalef's index, which indicates heavy pollution by organic material at these habitats (Hanna and Shekha, 2015).

5. Conclusion

Prior to this study, the aquatic fauna of Qatar was poorly known, with only few species recorded (Abdu and Shaumar 1985; Kardousha 2016). Current study outlined the patterns of composition and distribution of different aquatic insects from the country. Moreover fluctuating diversity patterns of aquatic insects are expected with the anthropogenic activities, which cause different levels of disturbance or provide more opportunities. The findings of this study are not conclusive and will contribute in future in-depth studies from the country. Further studies are needed to identify the positive or negative impact of environmental changes on entomofauna.

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