DOI: 10.24996/ijs.2022.63.8.5

ISSN: 0067-2904

Biodiversity and Structure of Rotifera Communities in the Great Garraf Drain Channel, Southern Iraq

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Received: 13/7/2021 Accepted: 17/10/2021 Published: 30/8/2022

Abstract

Three sites, selected on the Great Garraf Drain Channel (GGDC) demonstrated the first ever study dealing with rotifers biodiversity features from August 2019 till July 2020. Seventy-two taxonomic units were identified. The high densities of rotifera ranged from 733.32 - 32300 Ind./m^3. *Brachionus urceolaris*, *Keratella quadrata* (long spin), *Keratella quadrata* (short spin) and *Syncheta obloga* were the most common relative abundance recorded in the index. In contrast the results of the constant index showed that there were nine constant taxonomic units. The species richness index was recorded from 1.489- 6.900. Jaccard presence similarity index revealed a strong link between stations 2 and 3 with a value of 83.30%. Hereinafter Shannon-Weiner diversity index recorded values ranging from 0.821-2.901 bit/Ind. The species uniformity index ranged from 0.296- 0.925. Nevertheless, the values of this index indicated no environmental stress on rotifera assemblage in the river environment. Also, it was concluded that GGDC was considered generally ranging from moderately polluted in some sites to highly polluted water in other locations during the study period.

Keywords: Channels; Rotifera; Main Drain Channel; Zooplankton.

التنـــوع الإحيــــــــائي وتركيـــب مجتمع دولابيـــــات مبزل الغــــراف الكبيــر، جنوب العراق

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الخلاصة

تم اختيار ثلاثة مواقع على مبزل الغراف الكبير من أجل اظهار الدراسة الأولى التي تتناول التنوع الاحيائي للدولابيات خلال آب 2019 حتى تموز 2020. تم تشخيص 72 وحدة تصنيفية. اظهرت الدراسة الحالية قيمة الكثافة الكلية للدولابيات فقد تراوحت ما بين 733.32–32300 فرد/ م^3. سجل دليل الوفرة النسبية الأنواع *Brachionus urceolaris* ، *Keratella quadrata* (long spin) و *Keratella*

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(short spin) *quadrata* و*Syncheta oblonga*اكثر الأنواع وفرة. بينما أظهرت نتائج مؤشر الثباتية وجود تسع وحدات تصنيفية ثابتة. تراوحت قيم دليل غزارة الدولابيات ما بين 1,489-6,9. أظهر مؤشر دليل جاكارد للتشابه وجود ارتباط قوي بين المحطتين 2و3 بقيمة 83.30٪. تم تسجيل مؤشر التنوع الخاص بشانون وينر فيما مابين 0,821-901 901 بت/فرد. تراوح قيم دليل تجانس ظهور الانواع من 0.296 إلى 0.925 ومع ذلك تشير قيم هذا المؤشر إلى عدم وجود ضغط بيئي على تجمع الدولابيات في بيئة النهر. وقد تم التوصل إلى أن قيم هذا المؤشر تتدرج مياه مبزل الغراف الكبير من مياه معتدلة التلوث في بعض محطات وأشهر الدراسة إلى مياه عالية التلوث في أخرها.

1. Introduction

The drain channel is a modern concept dealing with withdrawing unused surface water from agricultural lands, streams and rivers to the main drainage [1].

Drains were established to reduce the salinization problem which is a scientific manifestation of desertification. The drainage process is not independent of the irrigation methods, but rather these two processes are linked to each other, as one affects and is affected by the other. It has been noted that the salinity blight limits agricultural productivity which is a direct threat to humans as it is a reason for eliminating their food [2] .

Food is important in human life in particular and living organisms in general [3]. Fish is one of the basic food sources that are widespread and cheap in various parts of the world [4]. Rotifera transfer vitamins, minerals and hormones to young fish and crustaceans because they are characterized by filter-feeding [5]. Several local studies have dealt with rotifer such as:[6-13]. However, this study, as it dealt with the effect of the Great Garraf Drain Channel water on the rotifer assemblies, also determines the impact of this drain channel on rotifer biodiversity.

2. Material and Methods

2.1 Study Area Description

The main drain channel is one of the largest and oldest irrigation projects passing through agricultural lands irrigated from the Tigris and Euphrates Rivers. It is 565 kms long and starts from Isaaci District ending in Khor Al- Zubair [14].

The Great Garraf Drain Channel (GGDC) is one of the main drainages, divided and backed up to the main drain channel. A Dutch company was hired for this project and hence, it is known as the Dutch Great Drain Channel. The idea behind its establishment was to irrigate and reclaim agricultural land. The average water discharge is 20 m^3/sec and is l217 kms long (Department of Main Drain Channel, 2018 Personal Communication). Three sites were chosen along the irrigation drain channel (Figure 1). **1. Site One:** This site was located on the northern sector of the Great Gharraf Drain Channel at 45.71.88"N, 32.17.36"E, on the western side of the Al-Gharraf River, about 25 kms south of Wasit Governorate, and GGDC is 7.44 m deep, 50 m wide from the top and 10 m from the bottom. **2. Site Two:** It represents mid sector of the Great Gharraf Drain Channel in the north of Dhi Qar Governorate, at 45.78.71"N, 31.85.29"E, and is2.6 m in depth, 25 m wide from the top and 12 m from bottom. **3. Site Three:** It was located on the southern sector of GGDC at 45.96.32"N, 31.48.55"E and is3.7 m deep, 20 m wide from the top.

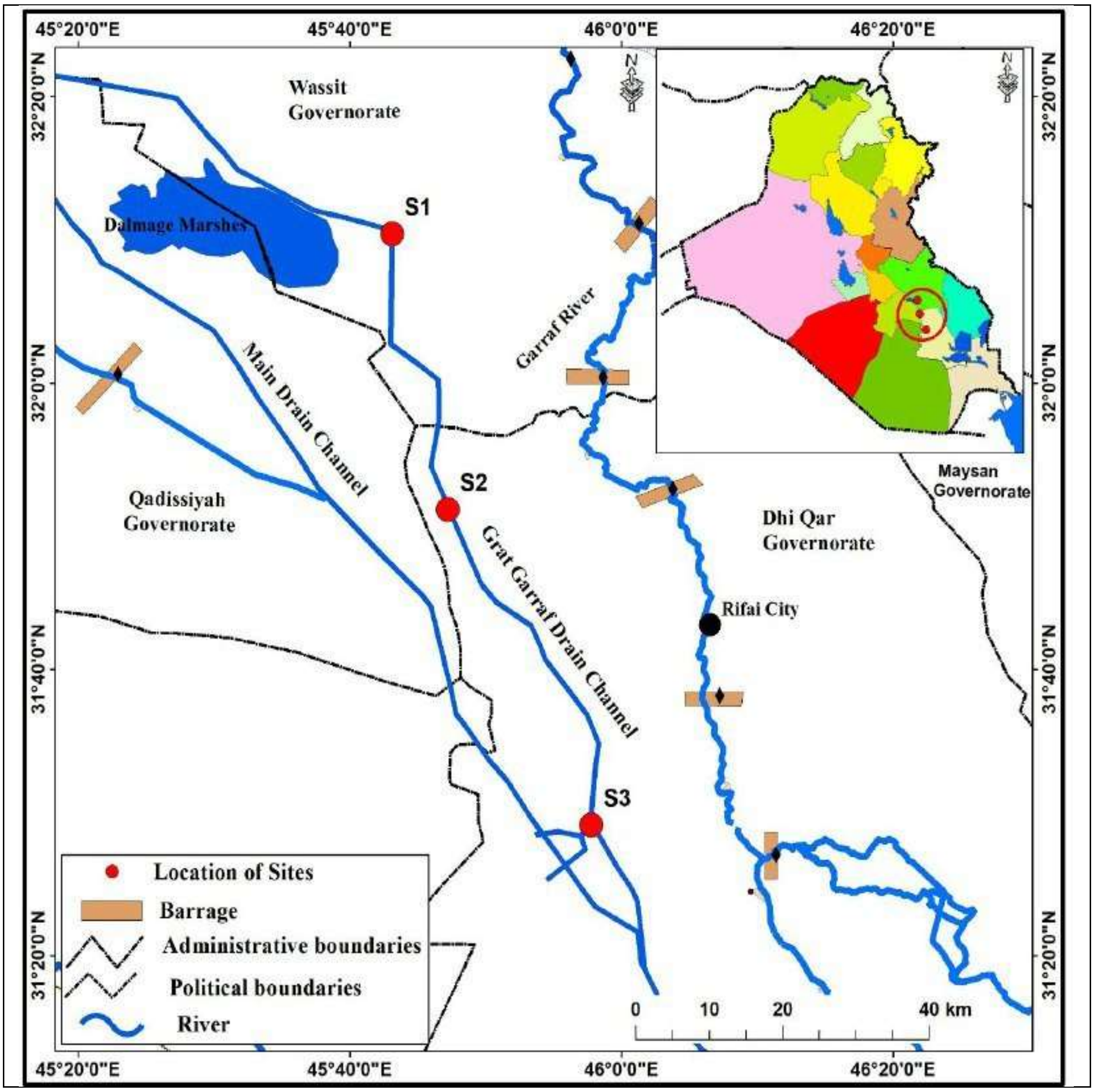

Figure 1-The study area with sites of samples collected. Source (Department of Main Drain Channel, 2018 Personal Communication).

Water discharges were from the lowest value of 2.1 m^3/sec. in September 2019 with the greatest value of 11.5 m^3/sec. in November 2019. The water velocity of the GGDC during the period of study was from the lowest value of 0.064 m/sec. in September 2019 while the greatest value was 0.3575 m/sec in November 2019 (Department of Main Drain Channel, 2019 Personal Communication) (Figure 2).

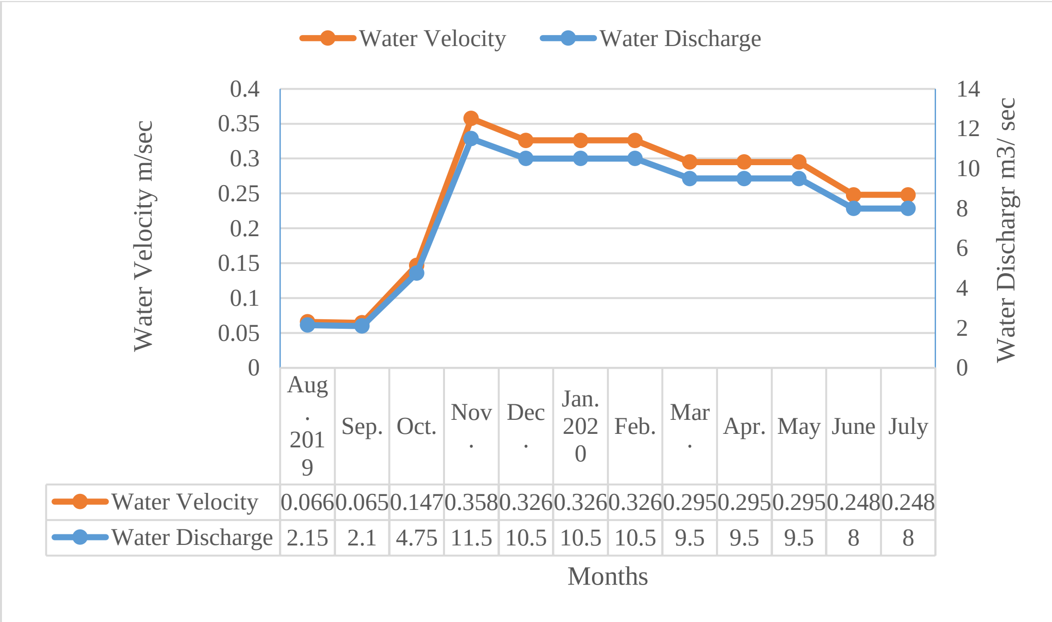

Figure 2-Water discharges and velocity of The Great Garraf Drain Channel during period study.

2.2 Rotifera Collection and Identification

Samples were collected monthly from August 2019 till July 2020 at a depth of 0.5 m. Forty liters were filtered through rotifer net with mesh size 55 µm by using a 20 liters graduated bucket. Later the samples were concentrated to 10 milliliters in a cylindrical container on the rotifer net and then 4% formalin was added to preserve the rotifer specimens. The species were identified according to the diagnostic keys below [15]; [16]; [17]; [18] and the results were expressed for individual/m^3.

2.3 Diversity Indices

The following Ecological Indices were accountable**:** Relative Abundance Index (Ra): Relative Abundance (Ra) was calculated depending on the formula used by Odum [19] Ra% = (N/Ns) χ100 where N: number of individuals at each taxonomic unit in sample; Ns total number in the sample. Species Richness Index (D) was calculated monthly according to the formula from Margalefe [20] D = (S-1)/ log N where S: species number; N: individuals total numbers. Jaccard presence – community**:** According to the formula of Jaccard [21] $\boldsymbol{ISj = \frac{C}{A+B-C} \times 100}$ where A = number of species at station A. B = number of species at station B and C = number of species found in both A& B stations. Shannon–Weiner Diversity Index (H) was calculated monthly using Shannon-Weiner's formula [22] H =-∑ ni/n χ Ln (ni/n) where ni: number of individuals per taxonomic unit; n: total summation of individuals. The results were expressed by a bit/individual unit. Species uniformity index (E) was measured by the formula of Neves *et al*. [23] E = H/Ln S where Ln S: diversity largest theoretical value; H: Shannon-Weiner value; S: taxonomic unit number in each site. Uniformity is in appearance if the value of the index is higher than 0.5, according to Pielou [24]. Constancy Index (S): was calculated according to the equation used by Serafim *et al*. [25] S = (n/N) χ 100 where n = positive sample number; N = total sample number.

3. **Results and Discussion**

In all under study sites, 72 new taxonomic units recorded in the GGDC were identified from August 2019 till July 2020 (Table 1). The differences in the number of taxonomic units in this study compared to previous studies could be due to a variety of factors, including the nature of the prevailing environmental conditions in the region, phytoplankton distribution, zooplankton body wall structure and the mesh size of the zooplankton net that controls the quantity and quality of zooplankton collected. Furthermore, these disparities can also be linked to the study's classification level [26].

The values of the total density of rotifera in the GGDC ranged from 733.32 Ind./ m^3 during July 2020 in site 1 and 32300 Ind./ m^3 during January 2020 in site 2 (Figure 3).

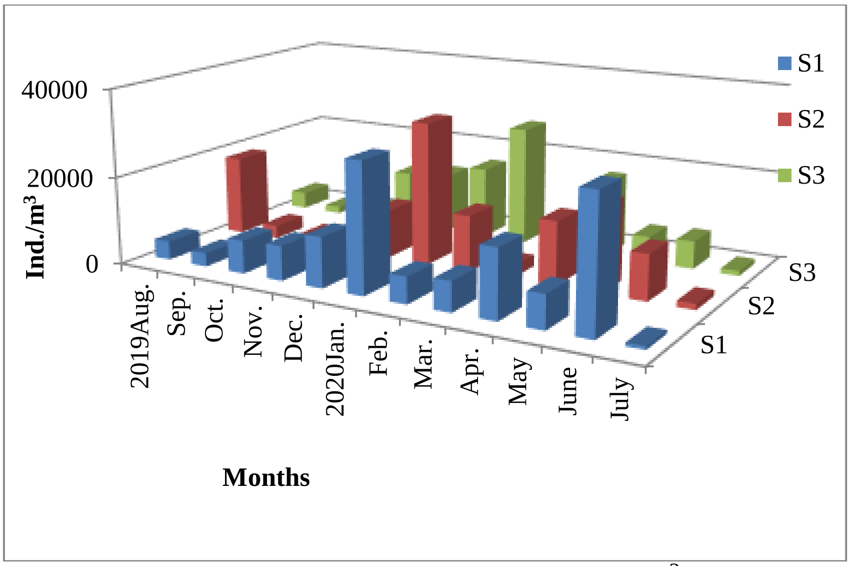

Figure 3 - Monthly variation of the rotifer total density Ind./ m^3 of the Great Garraf Drain Channel during the period study.

In terms of temporal variation, rotifera density was highest in the winter and spring which could be due to the presence of macro phytoplankton as rotifera rely on diatoms and share a nutritional relationship with them, depending on the availability of appropriate conditions in their environment [27].

Whereas the temporal decrease in the rotifera density in the summer may be due to the increased temperature and decreased dissolved oxygen which is incompatible with the fact that rotifera are oxygenophilic creatures, meaning that the lack of adequate oxygen causes their density to drop or perhaps as a result of low eutrophication and the presence of prey fish and aquatic invertebrates [28].

The highest density of rotifera was recorded on site 2 which may be due to the presence of aquatic plants that perform photosynthesis thus leading to high dissolved oxygen and the preparation of rotifera feed for algae and diatoms.

As mentioned by Baranyi *et al*. [29], water velocity controls the rotifera density and its abundance, as it decreases or is absent when the water velocity is more than 0.4 m/sec. The average velocity inGGDC ranged from 0.0645-0.3575 m/s which could be due to the low flow that helped to increase rotifera assemblage.

The relative abundance index of rotifers on site 1 indicated that *Brachionus urceolaris, Keratella quadrata* (short spin), *Brachionus angularis* and *Rotaria neplunia*, *Keratella quadrata* (long spin) were recorded as 16%, 14%, 10%, 10% and 8%, accordingly. Whereas the rotifers relative abundance index values on site 2 showed that *Brachionus urceolaris, Keratella quadrata (*long spin*)*, *Syncheta oblonga*, *Rotaria neplunia and Brachionus plicatlus* were recorded as 22%, 14%, 14%, 8% and 7%, respectively. Site 3 had relative abundance index values of rotifers showing that *Syncheta oblonga*, *Brachionus urceolaris, Keratella quadrata* (long spin) *and Rotaria neplunia* were recorded as 18%, 9%, 9% and 7%, respectively. The most abundant species recorded among rotifera in the GGDC belonged to the *Brachionus, Keratella* and *Syncheta* genera. The abundance of *Brachionus* and *Keratella* species was due to their parthenogenesis reproduction and short life cycles under suitable conditions as seen by Akin-Oriola [30]. While Syncheta species abundance may be linked to the its ability to escape excessive salt concentrations in the GGDC during early stages, a circumstance congruent with what Oltra and Todoli found [31] when they studied *Syncheta cecilia* where they showed that the generation time shortened with an increase in salinity and temperature. This was also confirmed by Nashaat's *et al.* [32] They focused on the *Brachionus calyciflorus*, concluding that the species' growth rate increased during the early stages of its development. Hence, it was concluded that *Syncheta* and *Brachionus* abundance may be due to the early stage’s tolerance to the GGDC salinity whereas this limit was lost after they grow up.

In addition, during summer there was a positive relationship between rotifera *Brachionus plicatilis* with salinity as shown by Yuan *et al*. [33].

Table 1-Abundance and constancy index of rotifer taxonomic units in the Great Garraf Drain Channel.

	Relative Abundance			**Constancy**		
Taxa Site	1	2	3	1	2	3
Anuroaeopsis fissa	R	R	R	A	A	A
Argonotholca	R	R	R	A	A	A
Argonotholca foliacea	R	0	R	A	0	A
Asplanecna priodonta	R	R	R	A	Ac	A
Aspelta	R	R	R	Ac	Ac	A
Brachionus angularis	La	R	R	C	C	C
B.bennini	R	0	0	A	0	0
B.bidentatus	R	R	R	A	A	Ac
B.calcyflorus calcyflorus	R	R	R	Ac	A	Ac
B.calcyflorus amphecerus (long spin)	R	0	0	A	0	0
B.calcyflorus amphecerus (short spin)	R	R	R	Ac	Ac	A
B.falcatus	R	0	0	A	0	0
B.forficula	0	R	0	0	A	0
B.quadridentatus	R	R	R	C	C	C
B.plicatlus	R	R	R	C	C	C
B.rubens	R	R	R	Ac	Ac	Ac
B.tariabilis	0	R	0	0	A	0
Brachionus urceolaris	La	La	La	C	C	C
Brachionus pterolinoides	0	0	R	0	0	A
Cephalodella aureculata	R	R	R	Ac	A	Ac
C.exigua	R	0	0	A	0	0
Cephalodella gibba	R	R	R	Ac	Ac	Ac
Colurella adriatica	R	R	R	C	Ac	C
Euchlanis delatata	R	R	R	C	C	Ac
Filina longiseta	0	R	0	0	A	0
Haringia	R	R	R	A	A	A
Hexarethra mera	R	R	0	A	A	0
Hexarethra vulgaris	R	R	R	A	A	A
Keratella cochlearis	R	R	R	Ac	Ac	Ac
K.tropica	R	R	R	Ac	Ac	Ac
K.quadrata (logn spin)	R	La	La	Ac	Ac	C
K.quadrata (short spin)	La	R	R	Ac	Ac	Ac
K. valga	R	R	R	C	Ac	Ac
Keratella serrulata	0	0	R	0	0	A
Lepadella ovallus	R	R	R	Ac	Ac	A
Lepadella salpina	R	0	R	Ac	0	A
L.elasma	R	R	R	A	Ac	A
L.hegurensis	0	0	R	0	0	A
L. luna	R	R	R	Ac	Ac	A
L.salpina	R	0	R	A	0	A
Lecan stichaea	R	0	0	A	0	0
Lophocharis salpina	0	0	R	0	0	A
Macrochaetus subquadratus	0	R	0	0	A	0

Manfredium eudactylotura	R	R	0	A	A	0
Monomata grandis	0	R	0	0	A	0
Monostyla bulla	R	R	R	C	Ac	Ac
M. closterocerca	R	R	R	C	A	A
M.hamata	R	R	R	Ac	A	A
M.quadridentata	0	0	R	0	0	A
M.lunaris	R	R	0	A	A	0
M.scutata	0	R	0	0	A	0
M.stenroosi	R	R	R	Ac	Ac	A
M.thalera	R	R	R	A	A	A
M. thionemanni	R	0	0	A	0	0
Mytilina nucronata	R	0	0	A	0	0
Notholca acuminata	R	R	R	Ac	Ac	A
Notholca squamula	R	R	R	Ac	Ac	Ac
Polyarthra dolicoptera	R	R	R	Ac	C	C
P.vulgaris	R	R	R	Ac	Ac	A
Pomopholyx sulcata	R	R	R	A	A	A
P. patulus	0	0	R	0	0	C
R.neplunia	La	R	R	C	C	C
Squatinella	R	R	0	A	A	0
Syncheta auriculata	0	0	R	0	0	A
Syncheta oblonga	R	La	La	Ac	C	C
Testudinella patina	R	R	0	A	A	0
Trichotria tetractis.	R	R	R	Ac	Ac	Ac
Trichocerca bicristata	R	R	R	Ac	Ac	A
T.elongata	R	R	0	A	A	0
T.porcellus	R	0	0	A	0	0
T.rousseleti	R	R	R	A	A	A
Trichocerca similis	0	R	R	0	A	A

*Relative abundance: > 70%: Dominant Species (D), 40%-70%: Abundant species (A), 10%-40%: Less abundant species (La). < 10%: Rare species (R).
*Constancy index: Frequencies calculated from% occurrence in samples. Accidental species (A) zooplankton occur in 1%-25%, Accessory species (Ac) occur in 25%-50% of samples and constant species (C) occur in more than 50%.

According to constancy index Table 1 shows that the following taxonomic units *Brachionus angularis*, *B.quadidentatus*, *B.plicatlus*, *Brachionus urceolaris* , *K.quadrata* (long spin), *Euchlaanis delatata* , *Polyarthra dolicoptera* , *Rotaria neplunia* and *Syncheta oblonga* were the most constant species and were frequently found in the GGDC, especially it constituted more than 50% of the samples taken from the drainage water. All taxonomic units were recorded with equal constancy index values during the period of study. Most of the taxonomic units that were repeated and in abundance were the same that were recorded with higher density.

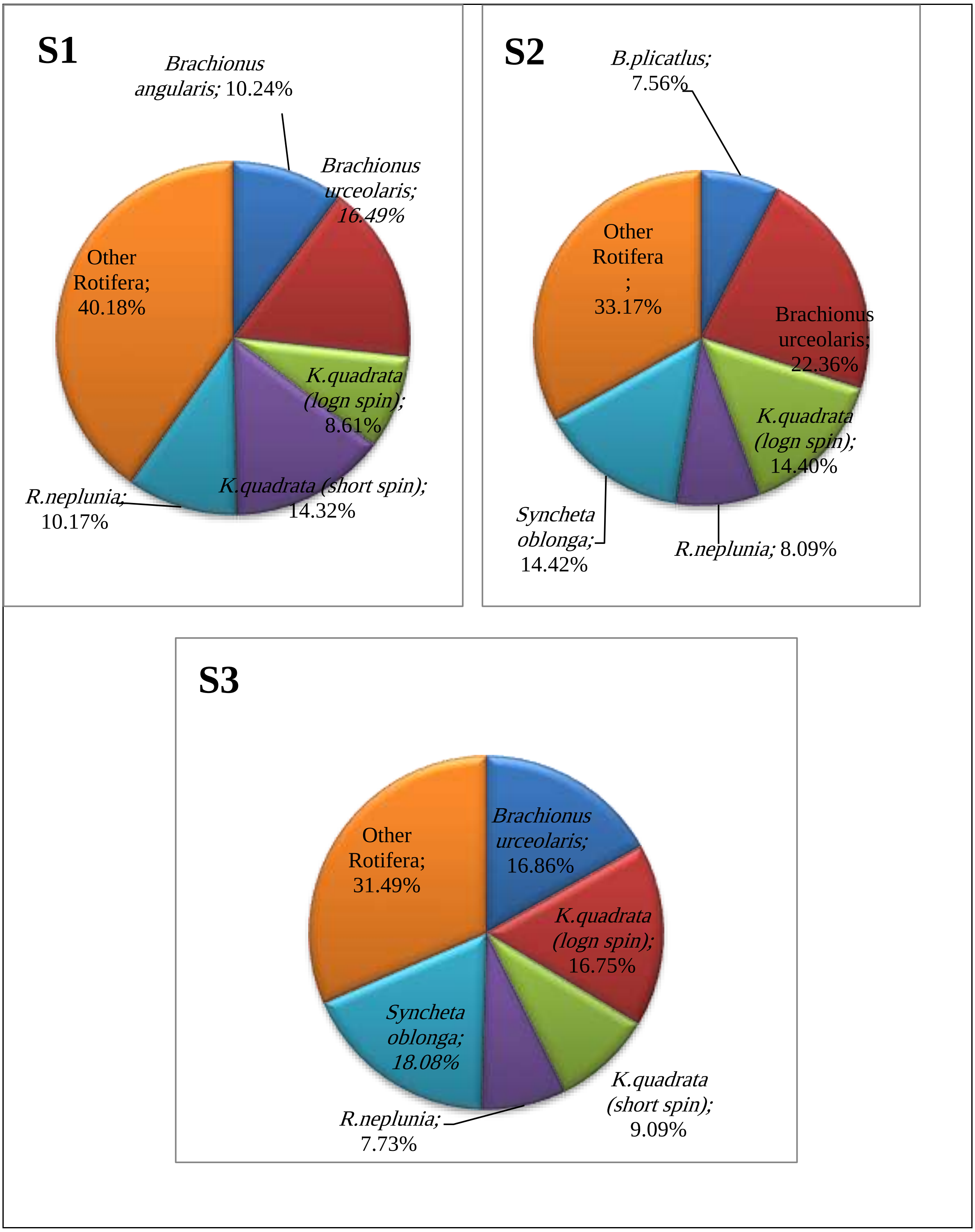

Figure 4-The dominant rotifer taxonomic units on the Great Garraf Drain Channel during the period study.

Figure 5 shows uniformity index values of rotifers, where the highest value reached 0.925 during September 2019 on site 1 and the lowest value recorded was 0.296 during November 2019 on site 3.

Since the value of this index exceeded 0.5 during the study period, it was shown that high values of the species uniformity index indicated the absence of environmental stress, making it a suitable environment for the rotifera community stability. Furthermore, these taxonomic units were considered homogeneous in appearance [34]. As for the spatial changes, the reason for the high uniformity index of the species may be due to the large presence of aquatic plants and high concentration of nutrients. The decrease in some sites was either due to the large number of pollutants dumped into the drainage or high turbidity.

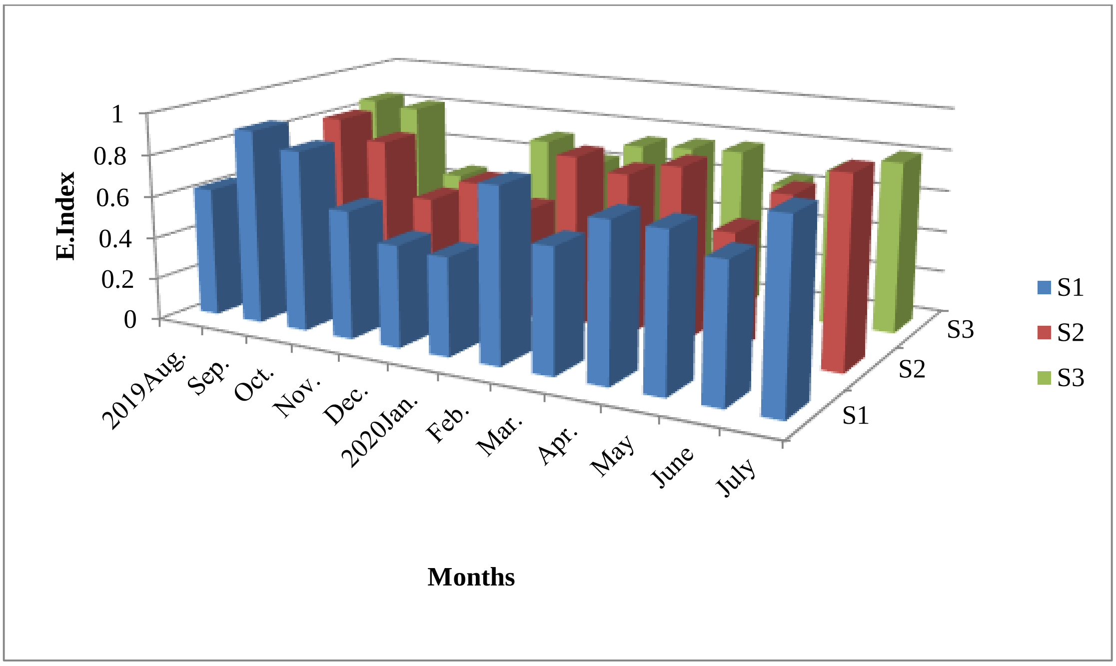

Figure 5- Monthly variation of the rotifera species uniformity index (E) for the Great Garraf Drain Channel during the period study.

Where the uniformity index value was (0.8- ≥0.9), it would be classified as highly balanced. Values from 0.6 to 0.7 were classified as moderately balanced and index value of (≤ 0.5) was classified as unbalanced or under stress [35]. Hence, GGDC was generally considered from unbalanced or under stress to highly balanced during 2019 in the study area.
As for rotifera Jaccard similarity index, higher Jaccard index percentages for rotifera populations between sites 2 with 3 reached 83.30%, followed by site 1 with site 2 recorded at 70.52%, and site 1 with site 3 reported a percentage of 67.82% (Table 2 and Figure 6).

Table 2-Jaccard's presence coefficient matrix among sites for rotifer count on the Great Gharraf Drain Channel during the period study

Step	Clusters	Distance	Similarity	Joined 1	Joined 2
1	2	16.6947346	83.3052654	2	3
2	1	29.4773922	70.5226078	1	2
Similarity Matrix Rotifera					
	S 1	S 2	S 3		
S 1	*	70.5226	67.8206		
S 2	*	*	83.3053		
S 3	*	*	*		

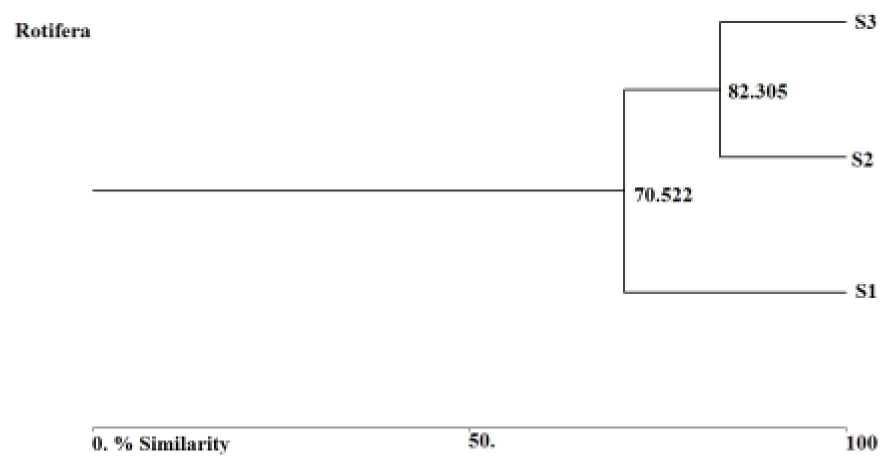

Figure 6-Dendrogram of Jaccard Index percentages of rotifers on the Great Garraf Drain Channel during the period study.

The high and low similarity values of rotifera in large scales when compared to other studies, may be explained by the presence of aquatic plants, algae and the increase in nutrient concentrations (nitrate and phosphate) throughout the period of study on all sites.

Regarding Shannon-Weiner diversity index of rotifera that ranged from the lowest value of 0.821 bit/Ind. during November 2019 on site 3 to the highest value of 2.901 bit/Ind. wasrecorded during September 2019 on site 1 (Figure 7).

Shannon index values were used to evaluate quality of thewater body. If the index value was more than 3bit/Ind, it would be classified as a clean condition, moderately polluted if the index value was between 1 to 3 bit/Ind. i and less than 1 bit/Ind. index value was classified as being heavily polluted [36]. Hence, GGDC generally ranged from moderately polluted in some sites to highly polluted water on the others during the study period.

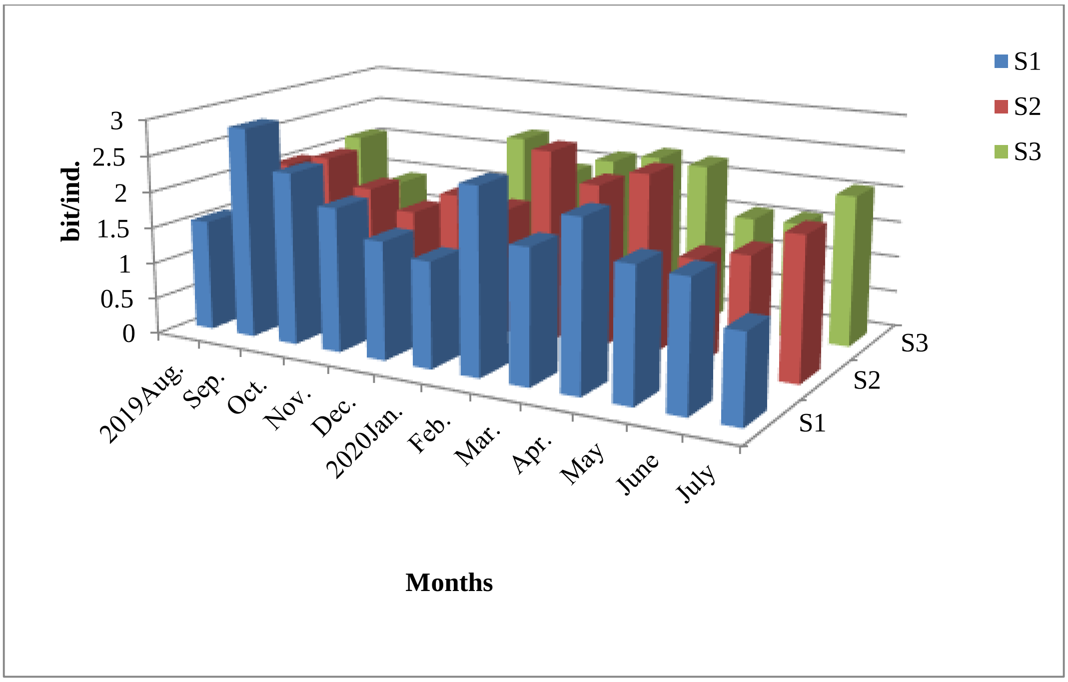

Figure 7-Monthly variation of rotifera Shannon-Wiener Diversity Index values (H) on the GGDC during the period study.

Shannon-Wiener index temporal variations values for rotifera were highest at the end of winter and in early spring, and it decreased at the beginning of winter. The spatial changes showed an increase in the values of this indicator for rotifera in site 1. The reason may be attributed to the increase in productivity in water [37]. Its decline in the site 3 could be the result of pollutants dumped into the drain channel.

The values of the species richness index of rotifera in the GGDC ranged from the lowest value of 1.489 during October 2019 in the site 3 to the highest value of 6.900 during December 2019 on site 1 (Figure 8).

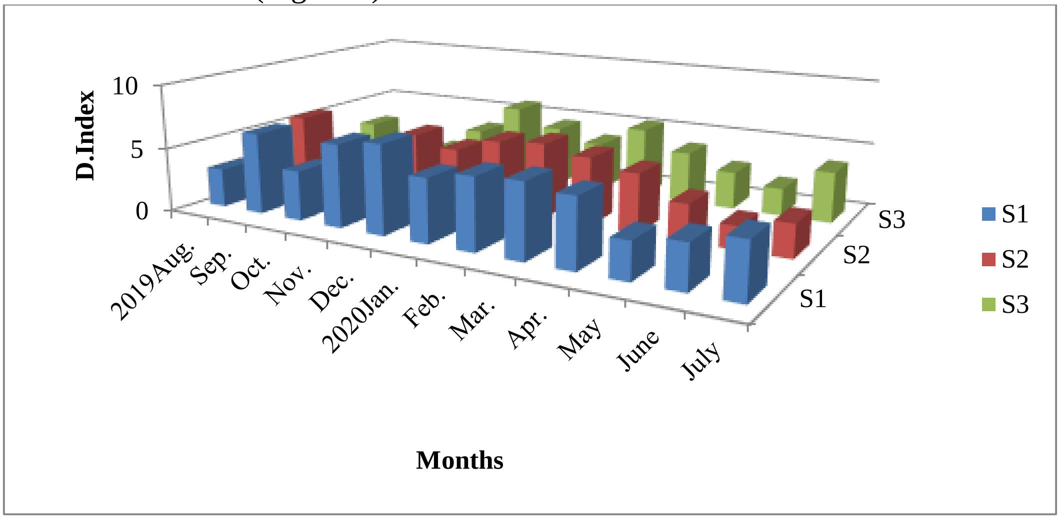

Figure 8-Monthly variation of rotifera species richness index (D) on the Great Garraf Drain Channel during the period study.

The temporal changes showed that the species richness value index of rotifera was highest from the end of the autumn to the beginning of the spring which may be due to an abundance of aquatic plants and food along the riverbed that did lead to rotifera distribution in benefiting from the food location [38]. In contrast the decline of species richness index of rotifera was at the end of spring which may be due to a lack of food and variation in physical and chemical properties.

As for the spatial changes in the rotifera species richness index values, they were recorded the highest on site 1 which could be due to many aquatic plants. Whereas their decrease in site 3 could be linked to high turbidity or lack of food [39].

The current study concluded that the low flow of the GGDC water helped to increase rotifera assemblage. In contrast, the species uniformity index indicated the absence of environmental stress which made it a suitable environment for rotifera community stability due to the value of this index exceeding 0.5 during the study period. In addition, some taxonomic units were considered homogeneous in appearance. Hence GGDC was generally considered from unbalanced or under stress to highly balanced during 2019 in the study area

On the other hand, Shannon-Weiner diversity index generally indicated that GGDC was considered ranging from moderately polluted in some sites to highly polluted water on other sites during the study period.

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