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Epiphytic Algae and Macroinvertebrates Communities of *Myriophyllum spicatum* Lemm and Their Cascade in the Littoral Food Web of Lake Nasser, Egypt

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Abstract: This study was carried out to investigate how Lake Nasser fish production may be utilizes *Myriophyllum* spicatum and/or its epi-communities. In order to do so, the distribution of epiphytic communities of *M. spicatum* in the lake littoral was investigated concurrently with the gut content of both some vertebrates and invertebrates. Epiphytic fauna and flora of *M. spicatum* in 6 embayment (khors) in Lake Nasser were sampled during March, 2006. In each khor, two littoral sites at three sections were investigated with total sites of 36. The study identified 179 epiphytic algal taxa in Lake Nasser: 55 Bacillariophyceae, 75 Chlorophyta, 47 for Cyanoprokaryotes and 2 for Dinophyta. Diatoms were peaked in Tushka east (TE), Kurusko (KR) and Gurf Hussein (GH)khors, whereas cyanoprokaryotes peaked in Klaabsha (KL) and KR khors. Chlorophytes marginally represented by the coccoide in KL and El-Ramla (RM) khors, while filamentous forms pulsed in TE and KL khors. A total of 21 species of living bottom invertebrates was identified in the collected macroinvertebrate samples. These include 13 Insecta, 2 Crustacea, 3 annelids, 3 Molluscs. Insecta occupied most population density (P.D.) of total macrobenthic fauna (68.14%), followed by Annelida (18.62%) and Crustacea (9.59%). The highest P.D. was recorded at IIS of RM khor. While the highest biomass value was recorded at IIN of RM khor. Epiphytic microalgae made a far greater contribution than macrophyte itself for macrobenthos species food. Epiphytic microalgae harbored as high as 95.0% for many invertebrates. Concerning fish guts, planktonic and epiphytic diatoms constitute about 47% of the algal counted in the fish guts followed by chlorophytes (31%), cynaoprokaryotes (19.2%) and dinophytes (1.8%). Epiphytic diatoms species were more common in the fish guts (about 86%), whereas plankton chlorophytes and cyanoprokaryotes were more common as compared with epiphytic groups. About 25% of the stomach contents of *Oreochromis. niloticus* Lemm were empty from animal materials. In the other guts, the animal materials were represented by small crustacea, some chironomid larvae, Hirudnae and some rotifers. *Lates niloticus* and *Alestes dentex* included more animal material compared with *O. niloticus*. Macroinvertebrates were represented by the fresh water shrimp *Caridina niloteca, Libellula* sp.*, Ischnura* sp., chironomid larvae and pupae, micronectidae, Trichoptera, copepods, cladocera and oligochaets.

Key words: Epiphytic microalgae · Macroinvertebrates · *Myriophyllum spicatum* · Species Cascade · *Oreochromis. niloticus*

INTRODUCTION

Myriophyllum spicatum is an invasive species [1], in 1993, *M. spicatum* was recorded in Lake Nasser, upstream of the Aswan High Dam [2]. Changes in the lake environment concerning with increased human activity (land reclamation, fish farming and tourist activities) associated with the flood events of the lake lead to high mass invasion of *M. spicatum* [3]. This species reportedly has displaced other aquatic plants; forming a weed bed that may cover a larger area than was originally present [3]. Mass increase of *M. spicatum* would expected to increase the lake productivity and increased complexity of the lake food web by providing substrata for periphyton colonization, increase abundant food production for many aquatic animals, increase habitat complexity, shelter as well as breeding area [4] and [5]. However, the plant itself is not thought to be preferred food, due to its low nitrogen content, high cellulose content and presence of allelopathic compound [6]. The plant-associated fauna and flora are more incorporated in different food web pathways than *M. spicatum* itself and different detrital sources because of the high quality of its epi-communities that contributed mainly to high content of proteins (amino acids), lipids (fatty acids) and other carbon molecules [7].

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Nile tilapia, *Oreochromis niloticus*, is the most common freshwater fish in Egypt, its relative percentage increased up to 80% to the total catch in Lake Nasser in recent years. *O. niloticus* is likely to derive its carbon (and other elements) ultimately from a mixture of benthic microalgae, phytoplankton and possibly some invertebrates [8] and [9]. However, the relative contribution of these components and the trophic linkages with tilapias may vary among water types and within species [10]. Various techniques are available to investigate diets, including gut content analyses, fatty acid profiles and stable isotopes. Gut content analyses are relatively easy and inexpensive to conduct; they provide good information on quality and quantity of ingested food.

The aim of the present study was to investigate how Lake Nasser fish production may be utilizes *M. spicatum* and/or its epi-communities. So, the distribution of epiphytic communities of *M. spicatum* in the lake littoral was investigated. Also, the gut content analysis of both vertebrates and invertebrates was studies to monitor the importance of *M. spicatum* and its epiphytic fauna and flora as diets for *O. niloticus* and other secondary consumers in Lake Nasser littoral area.

MATERIALS AND METHODS

Study Sites Description: The construction of the Aswan High Dam (AHD) in the southern part of Egypt (Aswan) resulted in the creation of one of the largest man-made reservoirs in Africa. It is confined between Latitudes 23° 58`N at the High Dam and 20° 27`S at the Dal-Cataract in the Sudan and between Longitudes 30° 07`W and 33° 15`E. The Lake stretches, over the Nubian valley south of the city of Aswan, for about 480 Km long and 16 km at its widest with a surface area of 6,000 km² at water level above 182 m [11]. The reservoir is divided into Lake Nasser in Egypt (about 300 km long) and Lake Nubia (about 180 km long) to the south in Sudan. The created reservoir consists of a very deep and long main channel extend in the north-south direction with many arms or embayment, that are locally called Khors, in the east-west direction at the two sides of the main channel (Fig. 1a). These khors are shorter, shallower and narrower than the main channel. The Khors are more eutrophied and fish production than the main channel. Sampling of macrophytes was surveyed during March of 2006. Samples were collected from six selected embayments (khors). The six selected Khors and their

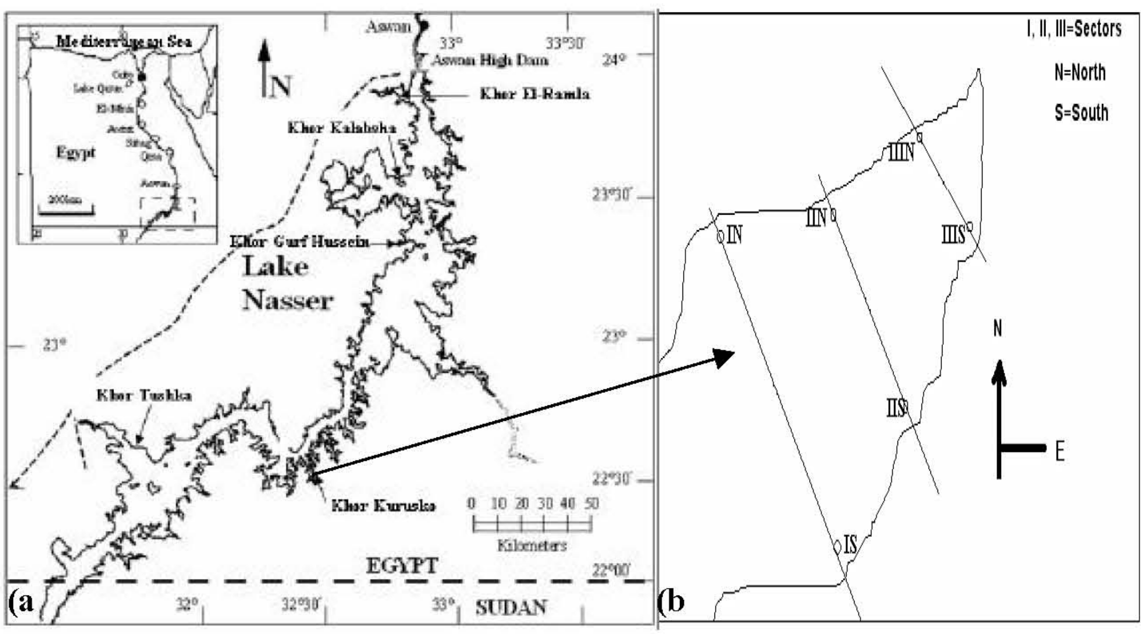

Fig. 1a,b: (a) Lake Nasser and the selected Khors; (b) Schematic diagram of the selected sections and sites inside sampling Khors abbreviations, were El-Ramla (RM), Kalabsha (KL), Gurf Hussein (GH), Kurusko (KR), Tushka east (TE) and Tushka West (TW). The two littoral banks (north and south) at three sections (I, II & III) inside each Khor were studied (Fig.1b).

Sampling

Macrophytes Collection: *Myriophyllum spicatum* samples were collected by metal square quadrate with 25cm inner edge. Randomly, the quadrate was put over the Macrophytes shoots; all shoots within the quadrate with the belowground material were carefully collected. These steps were repeated 3 times at each site. Epiphytic communities were separated from the plants by vigorous shaking for 3 minutes with filtered Khor water, the shaking process was repeated several times to sure that the attached communities were completely separated. The final volume was completed to 10L. About 100ml of the epiphyte suspension was passed through a 300µm mesh to avoid contamination with small macrophytes fragments for microalgal biomass measurements and species identification. The remaining de-attached community in the bowel was used for the analysis of macroinvertebrates.

Chl a and Algal Community Analysis: GF/C filter papers were used for chlorophyll-a (chl-a), the filters were socked in 10ml hot ethanol [12] and [13]. Phytoplankton samples were fixed with Lugol's solution enumerated and counted using the inverted microscope method [14]. Identification of the main phytoplanktonic groups was made with reference of: Cyanoprokaryota [15], Bacillariophyceae; [16] and Chlorococcales; [17] and [18].

Macroinvertebrates: The collected macroinvertebrates specimens was transferred to labeled bottles preserved in 4% formaldehyde and transported to the laboratory for further investigation. In the laboratory, collected specimens were thoroughly washed by a suitable flow of tap water to remove the mud and the preservative through a metal sieve (500 ìm mesh size). Samples were then poured in a white-bottomed tray of appropriate size and the animals were gently separated from the mud and plant debris by using a fine forceps and good visualization under binocular microscope.

Each group was counted and weighed after drying on filter papers for five minutes to remove excessive water adhering to their bodies. Every species was kept in a glass bottle with 7% formalin and labeled for identification. The biomass of animals was expressed in gram fresh weight per square meter (GFW/m^2).

Stomach Contents of Some Macroinvertebrates: Stomachs of some macroinvertebrates (freshwater shrimp *Caridina nilotica*, the gastropod, *Gyraulus ehrenbergi* and the larvae *Polypedilum* sp.and Dytiscid larvae) from different sites were investigated. The alimentary tracts were removed from the body of every organism and the stomach was carefully dissected and the microalgal contents were preserved and examined as mentioned above.

Stomach Contents of Some Fish Species: Stomachs of different fish from different sites were investigated. Fish were weighed to the nearest g and measured to the nearest mm. The alimentary tracts were removed from the body of fish, the stomach was carefully dissected and the contents were put in 200 ml plastic bottles and completed to the nearest fixed volume. Subsamples were used for algal examination as mentioned before. Macroinvertebrates were picked out and put on filter paper. Each of these content was weighed and put separately with a ticket in jar containing 6% formalin solution with few drops of Rose Bengal (1g/ liter) to preserve the material and stain it for later examination.

The stomach content weight index (SCWI) was calculated according to the following formula:

$$SCWI=\frac{\text{Stomach Content weigh}}{\text{Body weigh}}\times 100$$

In the laboratory, the content of each jar was examined by using a research microscope and the food items were identified to the lowest identifiable taxonomy. The data obtained were analyzed by using the occurrence method [19].

The Selectivity Index: The selectivity index for both *O. niloticus* and the common invertebrates were also calculated [20].

$$E = (r_i - P_i)/(r_i + P_i)$$

Where E is the selectivity value, r_i and P_i are the relative proportions of species *i* in the diet and the environment (the menu), respectively. The equation gives values between +1 and -1. Significant positive and negative E values indicated that the amount of a particular taxon in the crop was either more or less than one would expect by chance.

Statistical Analysis: Diversity, evenness and richness indices were developed by Primer 5.0 soft ware package. ANOVA analysis was performed using Statistica V. 8. Canonical correspondence analysis (CCA), a multivariate technique, was used to summarize changes of epiphytic assemblage's abundance in relation to macroinvertebrates abundance using correlation analysis. CCA was performed using CANOCO V. 4.0 [21].

RESULTS

Epiphyton

Epiphyton composition: A total of 179 epiphytic algal taxa was identified in Lake Nasser: 55 Bacillariophyta, 75 Chlorophyta, 47 for cyanoprokaryotes and 2 for Dinophyta. Diatoms were peaked in TE, KR and GH with the pulse of small size pinnate taxa *Cymbella microcephala* Grun., which has total relative abundance of 24.4% and significant spatial variation (P<0.001). The other cymbelloide species, *C. obscura* Krasske, constitute more than 10% of the total epiphyton communities; it was highly developed in KR, especially at the northern sites, whereas it was least in KL and TE. Other pinnate diatoms, *Epithemia argus* var. *intermedia* Kuetz. and *Fragilaria construens* (Ehr.) Grun. were partially present, especially in the northern khors. The share of centric diatoms to total abundance was very low. The epiphytic filamentous cyanoprokaryotes were more important if compared with the coccoid forms. Both forms peaked in KL and KR with *Phormidium papellaterminatum* Kiss. and *Gomphosaeria nageliana* (Unger) Lemm, respectively. The filamenous forms had a climax in TE with *Oscillatoria plnanctonica* Wolosk, while *Lyngbya limnetica* Lemm was more present in RM. Although chlorophytes were well represented in both frequency and occurrence, their share of total abundance was low. They marginally represented by the coccoide *Chlorella* spp. in KL and *Rhadiococcus nimbatus* (Wild.) Schm. in RM. The filamentous *Stigeoclonium tenue* (Agard.) Kuetz pulsed in TE and KL with relative abundance of 8.2 and 6.7%, respectively.

Richness, Evenness and Biodiversity of Epiphyton: Both diversity and richness indices of epiphyton were highest in KL; slightly decrease in RM, then gradually decreased southward. Completely even distribution (each species has the same abundance) gives an evenness index of 1. Completely dominance of only one species gives an index of 0. The evenness index shows semi-equitability for epiphytic species distribution in Lake Nasser with values ranged between 0.3 at IS in KR and 0.78 at IS in RM. The evenness index average was highest in KL but least in GH due to the clear dominance of *Cymbella microcephala.* In Lake Nasser, epiphyton diversity seems to be closer correlated to evenness than to species richness. ANOVA analysis reflects a significant (P<0.01) variation for both diversity and evenness between different Khors and inside the Khor itself.

Epiphyton Abundance and Chlorophyll a: The total epiphytic abundance had a peak of 2585.7 cells x 10^3/cm^2 at GH and then decreased in the two opposite directions to reach a minimum abundance of 1072.3 cells x 10^3/cm^2 in KL then marginally increased in RM (Fig. 2). The total epiphytic abundance was lower at the middle section compared with the other sections. Chlorophyll a was highest in the khors in the two ends of the lake with the highest regional average value of 219.3μg/cm^2 in RM, while chlorophyll a values were minimal in the middle of the lake with minor peak of 144.3 μg/cm^2 in KL. Although chlorophyll a values were spatially varied, its variation was not significant. Chl a showed a major peaked of 492μg/cm^2 in RM at III N, while a minor one of 43.6μg/cm^2 was measured in GH at IS. The siliceous epiphytic algae were the most dominant; they have a relative abundance of 62.08%. Diatom density distribution showed irregular trend neither among Khors nor inside the Khor. The spatial variation in diatoms abundance in the Khor littorals (north and south) was not significant, while the variations between the Khor was significant (P<0.001). A climax (2629.1 cells x 10^3/cm^2) of bacillariophytes was recorded in the middle lake Khor (GH) remarkably decrease in the two opposite directions, showed a minor regional average of 299.5 cells x 10^3/cm^2 at KL. Cyanoprokaryotes were highest in KR then sharply decreased in GH, followed by a gradual increase northward till RM. Cyanoprokaryotes gradually increased from the mouth towards the end of the Khor. Both the highest and least cyanoprokaryotes abundance of 2014.7 and 3.1 cells x 10^3/cm^2 were detected in IIIN and IN in RM, respectively. Chlorophytes peaked in the middle Khors (GH and KL), decreased in the southern and northern Khors. Chlorophytes were minimum at the middle section, harbored a climax at the most inner section. The chlorophytes taxa were much higher at the northern side of the khors (about 2.5 fold) compared to the southern one. The maximum abundance of 793.2 cells x 10^3/cm^2 was reported at IIIN in Kalabsha while the minimum of 24.0 cells x 10^3/cm^2 was obtained at IS in Rm.

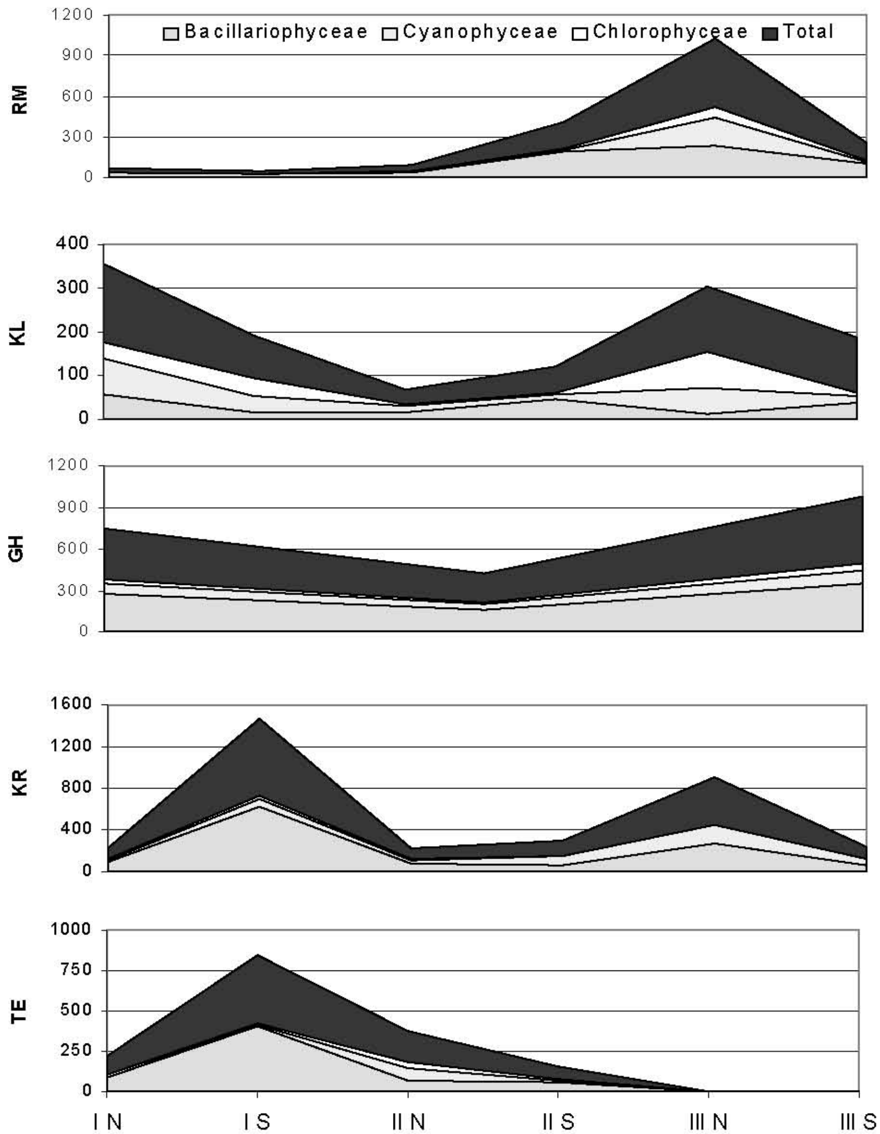

Fig. 2: Distribution of epiphytic community in sampling Khors (cells x 10^3/cm^2)

Macroinvertebrates

Community Composition and Relative Abundance: A total of 21 species of living bottom invertebrates were identified in the collected macroinvertebrate samples. These include 13 Insecta, 2 Crustacea, 3 annelids and 3 molluscs. Insecta occupied most population density (P.D.) of total macrobenthic fauna (68.14%), followed by Annelida (18.62%) and Crustacea (9.59%) (Fig. 3). The *Chironomus* sp showed the highest P.D. of macroinvertebrate species in all sampling khors with average of 771 org./m^2 especially in KR and TW. It followed by the oligochaete *Pristina* sp (409 org./m^2). Concerning biomass, Crustacea occupied the first position (68.34%) which is mainly attributed to the freshwater shrimp *Caridina nilotica* (Roux). It followed by Insecta (25.48%), Mollusca (5.18%) and oligochatea (1%).

Spatial Distribution of Total Macrofauna: Distribution of macrobenthos in different sampling sites showed remarkable spatial distribution changes from site to another. Distribution of epiphytic macroinvertebrates changes from a khor to another, furthermore, it also varied between the sites within the same khor. RM was the

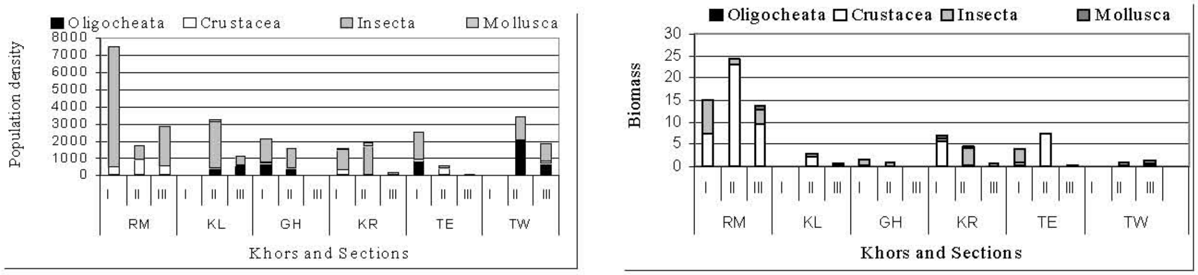

Fig. 3: Percentage of population density (organisms/m^2) and biomass (GFW//m^2) of different macroinvertebrates groups in different Khors and sections (I, II and III).

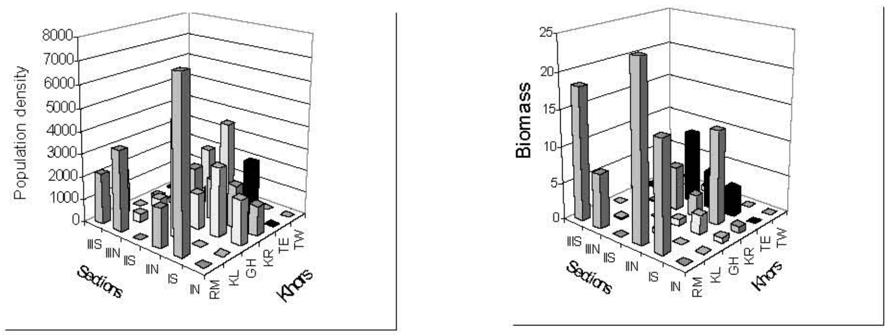

Fig. 4: Population density (Organism/m^2) and biomass (GFW//m^2) of total invertebrates associated with plants in the investigated area

most productive khor in the lake followed by KL. The highest P.D. (7488 and 5008 organisms/m^2) was recorded at IIS of RM and IIN of KL, respectively. This is mainly due to increase number of Insecta. On the other hand, the lowest P.D. (64 organisms/m^2) was recorded at IIIS in TE (Fig. 3). Biomass distribution of macrobenthos weight in different sampling sites was different from number distribution. The highest biomass values (24.18 and 18.39 GFW/m^2) were recorded at IIN and IIIS of RM, respectively. This is mainly due to increase number of freshwater shrimp *Caridina nilotica* and some species of Mollusca (Fig. 4).

Concerning different groups of macrobenthos, Insceta was the most common group in the investigated area. It was represented by 13 species Dytiscid larva, *Ischnura* sp., *Libellula* sp., *Caenis* sp., *Hydrovatus* sp., *Micronecta* sp., *Cryptochironomu* sp., *Procladius* sp., Tanytarsus sp., larvae and pupae of *Chironomus* sp., *Polypedilum* sp., Trichoptera sp. Insecta group was common in all sections but with different values. The highest density was recorded in RM at section III. On the other hand, the lowest value was recorded at section II of TE (Fig., 4). The same trend of distribution was recorded for biomass (Fig. 3). The highest densities of Mollusca were recorded at section II of KR with a value of 232 organisms/m^2. The species of this group disappeared in most sampling sites. The same trend of distribution was recorded for biomass (Fig.4). However, Crustacea was represented by two species namely *Caridina nilotica* and *Stenocypris malcolmsoni*. The highest P.D. was recorded in all sites of RM. Section II was the most favorable grounds for crustacean species, where P.D. of 869 Organisms/m^2 was recorded (Fig. 4). Biomass exhibited the same trend of distribution (Fig. 4). Three oligochaete species (*Pristina* sp., *Limnodrilus hoffmnisterii* Claparède, *Helobdella conifera* Moore) were recorded in the sampling sites. These species were recorded in most sites especially TE (Fig. 4).

Epiphyton and Macroinvertebrate Association: The epiphytic microalgae and macroinvertebrates relationship showed two different spatial associations. A negative association between Khors (R=-0.64 and R=- 0.79, for density and biomass, respectively) and a positive one inside Khors (R=0.66 and R= 0.5, for density and biomass, respectively) as presented in (Fig. 5). In average, the highest density and biomass between sections were detected at IIIN for both macroinvertebrates and

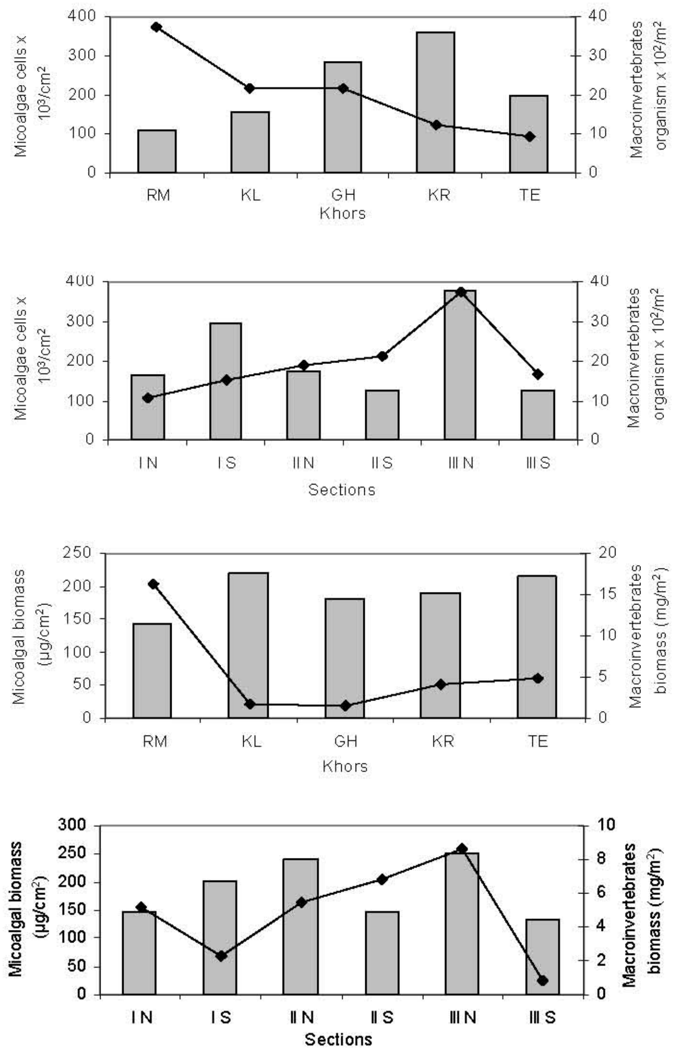

Fig. 5. Average macroinvertebrates and micralgal association in Khors and sections (micralgal biomass and density represented as column on the primary axis and macroinvertebrates biomass and density represented as line at the secondray axis). Population density; above curves, while biomass; lower curves

microalgae. Whereas, the lowest values of biomass and population density were not associated for macroinvertebrates and microalgae. The highest densities for micoalgal of 358565.4 cell/ cm^2 and macroinvertebrates of 2181.3 org/cm^2 were measured in the northern Khors, KR and KL, respectively. The highest biomass for micoalgal of 358565.4 µg/ cm^2 and macroinvertebrates of 2181.3 mg/cm^2 were measured in KL and RM, respectively. The CCA analysis revealed that (Fig. 6), the total micoalgal density was not affected by total invertebrates and their groups. The microalgal groups were deferentially responded to invertebrates. Diatoms were positively associated with Insecta, Olegocheata, Crustacea and total macroinverebrates, whereas both Cyanoprokaryotes and chlorophytes were negatively related. Both epiphytic microalgae and macroinvertebrates were highly correlated at axis 2, both axis were responsible for only 32% in the variation of epiphytic microalgae.

Macroinvertebrates Guts Content: Epiphytic microalgae made a far greater contribution than macrophyte itself as food for macrobenthos species. The dietary preference of macrobenthos for different dietary items contribution changed from one group to the other and within the same group. Epiphytic microalgae were found as high as 95.0%

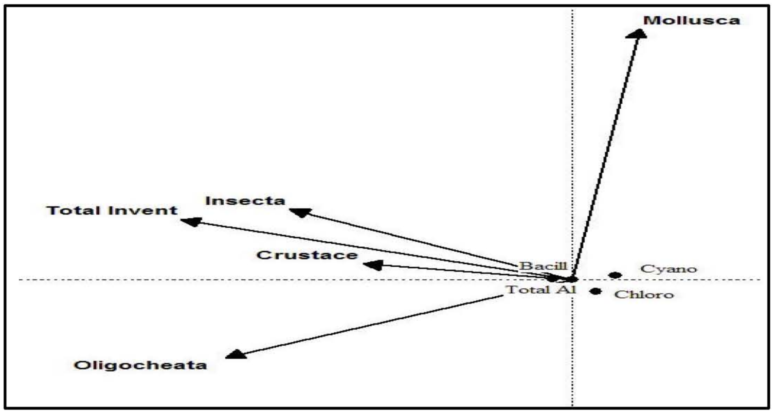

Fig. 6: Canonical correspondence analysis of total and different epiphytic groups, dependent variables, in relation to different macroinvertebrates groups, independent variables.

in different macroinvertebrates except for Dytiscid larvae, *Polypedilum* sp and *Gyraulus ehrenbergii* Beck. On the other side, phytoplankton species were negligible in different macrobenthos guts. Algae and macrophyte were consumed in relatively large quantities by co-occurring in the guts of the shrimp *Caridina nilotica*. The diatoms, *Epithemia* sp. and *Cymbella* sp. were the most common species, whereas other epiphytic diatoms and filamentous chlorophytes were rarely present.

The mollascan species, *Gyraulus ehrenbergii*, preferentially fed on organic detritus followed by diatoms. The small size, gelatinous stalked growing *Gomphonema* sp., was the most preferred diatoms. The other small size diatoms, specifically *Cocconeis placentula*, were considerably co-occurred. The two Insecta, *Dytiscid* and *Polypedilum* sp. larvae were essentially fed on plant fragment and/or detritus in addition to diatoms as main epiphytic microalgae food source.

Guts Contents Composition in Collected Fish

Epiphytes Composition: Considerable samples were available for *O. niloticus*, whereas the samples available for the other species, *Lates niloticus*, *Hydrocynus forskalii*, *Alestes dentex* and *Sartheroodon galilaeus* were considerably rare. The fish gut contents differed significantly among sampling sites and different khors. Microalgae were highest in different *O. niloticus* specimens, independent of site of collection, if compared with other fishes specifically *Hydrocynus forskalii.* Microalgae in fish guts spanned a broad range from 35 x 10^2 cells gut^{-1} in *Hydrocynus forskalii* to 238806.2 x 10^2 cells gut^{-1} in *O. niloticus*. Diatoms constitute about 47% of the algal counted in the fish guts followed by chlorophtes (31%), cynaoprokaryotes (19.2%) and dinophytes (1.8%). Epiphytic diatoms species were more common in the fish guts (about 86%), whereas plankton chlorophytes and cyanoprokaryotes were more common compared with epiphytic ones. The epiphytic species *Epithemia sorex* Kuetz. and the plankton *Melosira granulata* (Ehr.) Ralfs. were the most frequent and abundant species in Nile tilapia guts. Whereas *Cymbella leptoceros* (Kuetz.) Grun, *Fragilaria pinnata* Kuetz. and *Navicula* sp were considerably present. *Microcystis* spp were more present in the specimens of *O. niloticus* collected from RM.

Macroinvertebrate: Animal materials which recorded in the stomach contents of fish species included Crustacea; Decapoda (*Caridina nilotica*), Copepoda, Cladocera (*Daphnia* spp.) and Rotifera (*Keratella* spp). Whereas Annelida included; Hirudina (*Helobdella* sp.) and Oligochaeta; Insecta included; *Libellula sp., Ischnura* sp., Micronictidae and Chironmid larvae and Chironomid pupae, in addition to fish eggs.

About 25% of the stomach contents of *O. niloticus* were empty from animal materials. In other guts, the animal materials were represented by small crustacea, some chironomid larvae, Hirudnae (*Helobdella* sp.) and some rotifers. The percentage occurance of crustacea was 69.2% of all *O. niloticus* alimentary tracts examined, Chironomid larvae occurred in 7.8% while Hirudunae and Rotifera occurred in 23 and 54%. The alimentary tracts of *Lates niloticus* included more animal material compared with *O. niloticus*. Macroinvertebrates were represented by the fresh water shrimp *Caridina niloteca, Libellula sp, Ischnura sp,* Chironomidae larvae and pupae, micronectidae, Trichoptera, Copepods, Cladocera and

Oligochaets. The occurrence percentages of *Caridina nilotica* and *Libillula* sp was 100% while *Ischnura* and Cladocera occurred in two thirds of alimentary canals. The other food items occurred in 33.3% of *Lates niloticus* guts. The guts of *Alestes dentex* contained Insects (chironomid larvae and pupae *Libellula* sp and *Ischnura* sp) and few ostracods. Guts of *Hydrocynus forskalii* contained chironomid larvae and pupae, *Caridina nilotica* few Trichoptera, fish eggs and bones. Occurance percentage of each previous one was 100%. The stomach content of *Sartheroodon galilaeus* contained very few copepods and rotifers.

The stomach content weight index (SCWI) showed no significant difference between six species. Relation to khors, the difference in SCWI of one species was obtained in different area may be explained by more food resources inhabited some areas so the feeding activity of the same species would be easily increased. According to species length, it was found that specimens measured less than 300 mm in length have higher SCWI values; contain great quantity of food in stomach. On the other hand, the longer specimens ingested relatively smaller amount of food. This means inverse relationship between the size of fish and its stomach content. As a general observation, the colour of stomach content as a whole was always olive green, this may be referred to the diatoms, colour they feed upon.

Food Selection: Macroinvertebrates feeding showed high selectivity towards the epiphytic diatoms, specifically the two insects, *Cryptochironomu* sp and Trichoptera, which used diatoms as a unique food source. The Chironomid pupa showed high selectivity towards chlorophytes and cyanoprokaryotes more than diatoms. The crustacean *Caridina nilotica* used gelatenious stalked diatoms, *Gomphonema*, as a main food source in addition to the host plant material and filamentous chlorophytes. *Dytiscid* larvae and *Polypedilum* sp feed on the plant fragment and epiphytic microalgae in equal parts. Organic detritus found only in *Gyraulus ehrenbergii* in addition to epiphytic diatoms. Diatoms *Gomphonema*, *Cymbella* and *Epithemia*; filamentous chlorophytes, *Stigeoclonium tenue*. and the filamentous cyanoprokaryotes, *Oscillatoria* were the most important epiphytic microalgae found in the invertebrate guts.

The results of the selectivity for *O. niloticus* revealed that amorphous detritus and sand particles are nearly absence from the fish guts which were full of the epiphytes microalgae and phytoplankton as major components. The selectivity values of a particular species varied from Khor to another with a broad range from -1 to +1. The epiphytic, odnate small taxa, *Achnanthes minutissima* Kuetz. and *Cymbella microcephala* have a negative selectivity values. Whereas the large odnate taxa, *Cymbella sileciaca* Bleisch and *Rhopalodia gibba* (Kuetz) O.M., have high positive selectivity values. The filamentous chlorophytes, *Stigeoclonium tenue*, has a highly significant positive selectivity values. Planktonic centric diatoms, *Cyclotella meneghiniana* Kuetz. *C. ocellata* Pant. and *Melosira granulata* were important components of the fish gut content. The coccoid cyanoprokaryotes, *Merismopedia elegans* Braun. and *Microcystis aeruginosa* Kuetz. were highly present with the chlorophytes *Asterococcus limneticus* Corda and *Pediastrum simplex* Meyen. All the planktonic forms have positives selectivity values, equal +1 in most cases.

DISCUSSION

The importance of periphyton communities in shallow, nutrient-rich ecosystems is based on the finding that many herbivorous fishes prefer feeding on benthic, epilithic or periphytic fauna and flora, rather than on small pelagic organisms [22]. Traditionally, these systems are regarded as phytoplankton production units in which inorganic nutrients and sunlight generate plankton biomass that can be harvested by herbivorous fish. Invasion of these systems with natural substrates stimulates the growth of attached organisms that are more easily harvested by fishes. This could make the conversion of primary and secondary productions into fish biomass will be more efficient. Periphyton in substrate ponds served as an additional food without reducing the pelagic productivity. The reported increase in fish production due to substrates ranged from 30 to 115% in carp monoculture [23] and [24], 30 to 210% in carp polyculture [25] and 60-71% in *O. niloticus* polyculture fish ponds [26] depending on several factors. Several experiments in which artificial substrates were added have shown that periphyton (defined here as the total assemblage of attached aquatic plant and animal organisms on submerged substrates) can increase the production of fish compared to systems without substrates [27] and [30] Our study confirmed these findings because, firstly, the standing crop of epiphytic flora and fauna were more important than the corresponding values for both pelagic and benthic taxa, will be represented bellow. Moreover, secondly, both epiphytic algae and invertebrates represent a major food source that highly consumed in the lake.

The standing crop of total macrobenthic invertebrates in Lake Nasser's Khors averaged 2026 org./m^2, weighting 5.29 G.F.W/m . ^{2}This average standing crop was higher than the corresponding values in the main channel of the lake during 1998 [31] and [32]. However, [32] showed that macrophytes which occur in dense beds protect invertebrates from grazers and provide them with accumulated organic matter for feed. This also agreed with the results of [5] who speculated that macrophytes provided excellent microhabitats of special characteristics that enhance the establishment and colonization of many epiphyton and invertebrates in Lake Nasser. Also, [33] suggested that microalgal biomass accounted for a higher percentage of the variation in invertebrates' densities than did plant biomass. These data suggest that when epiphytic food is available, herbivore density should increase because immigration rates would increase while the relative emigration rate decreases with continues renew of the resource. Additionally, macrophytes can mobilize inorganic nutrients (nitrogen, phosphorus and other micronutrients) from the rich sediment to the overlaying microalgae and their microhabitats so as to enhance their production to the levels of 210 cell X 10^4/cm^2 compared with the poor ambient water production that averaged 107 cell X 10^3/l [34]. Also, the submerged stem with the whorled dissected leaves of *M. spicatum* can trap planktonic algae and detritus that could enrich the epiphyton [35] and [36].

Results from the gut content of macroinvertebrates indicated that greater amounts of food particles including microalgae were ingested. Epiphytic microalgae and algal filaments were found to be significant components of the diet of these grazers. It was found that rates of consumption by macroinvertebrates in shallow meadows averaging 57% of the annual epphytic primary production, since herbivores mostly consume the older parts of the leaves that are more heavily colonized by erect epiphytic algae [37]. Microalgae are preferable food over not only the host plant but macroalgae as well. Isotopes signatures was used to conduct that a large group of fauna species in plant meadow have $\delta^{13}C$ signatures comparable to epiphytes and the macroalgae *Sargassum* [38]. Since the abundance of *Sargassum* was low inside the meadow compared to epiphytes, they identified epiphytes as an important food source in the food web of this meadow. The authors reported that epiphyte signature could be identified over the whole food web, ranging from invertebrate grazers up to top predators. At the species level, it was reported that the degree of selectivity is dependent on the biomass level [39]. At the lowest biomass level, selectivity-values scattered quite widely among species. At the higher biomass levels the unicellular diatoms and the gelatinous stacked showed high selectivity indices. Macroinvertebrates appear to become less selective with increasing food biomass. This may explain the less selective feeding of macroinvertebrates towards specific species.

Tilapias are often the dominant grazers in most African freshwater habitats and may represent an important component in the food web dynamics of these ecosystems [40]. Tilapias may encounter different sources of foods; resulting in diet shifts within the same location [41]. The present observation confirmed that *O. niloticus* tend to eat more microalgal material than food of animal origin. Results of gut content analyses were generally in agreement with the assertion that *O. niloticus* is mainly a generalist herbivore, which easily shifts diets depending on food availability. Moreover, occurrence of diatoms was not less than 90% and reached to fullness in some localities. However, there seems to be greater ingestion for microalgae and in rare cases epiphytic invertebrates also were consumed. Conversely, host plant tissues may be ingested during the general grazing process, but not readily assimilated [42]. Although it was impossible to separate periphytic and planktonic portions of gut contents, efforts had been made to check whether there was a significant presence of periphyton in guts of tilapia. The selectivity index suggests that there were considerable epiphytic foods in the tilapias guts. From the selectivity indices, tilapias showed a high positive selection for epiphytic diatoms specifically *Gomphonema* spp, *Epithemia* spp, *Cymbella* spp and *Rhopalodia* spp. It was postulated that tilapias are responsible for biomasss reduction happened in epiphytic community especially those are originally attached (diatoms) [29] and [30].

The Nile tilapias were selectively feed on coccoid cyanoprokaryotes whereas; macroinvertebrates had a good number of positive selections for filamentous forms. chloroococales species were considerably present in the tilapias guts. In this respect, it was concluded that *Microcystis* and *Merismopedia* were the most abundant genera in the cyanoprokaryotes in diet of tilapias sampled from two Ethiopian Rift Valley lakes, Awasa and Zwai [43]. Green algae (*Ankistrodesmus, Pediastrum* and *Closterium*) and cyanoprokaryotes (*Anabaena, Oscillatoria* and *Microcystis*) were found in Nile tilapia stomach from the Nile River, Egypt [44]. The cell counts of phytoplankton in water filtered by tilapias indicated significant reduction in green algae and cyanobacteria [45].

Although macroinvertebrates individuals were a minor component of tilapias guts, they constituted a fundamental part of the carnivorous and piscivores fishes guts detected during this study. *Caridina nilotica, Libellula sp., Ischnura sp.,* Chironomid larvae and pupae, Micronectidae, Trichoptera, Copepods, Cladocera and Oligochaets were present in the guts of the pascivirous and carnivorous fishes, *Lates niloticus, Alestes dentex and Hydrocynus forskalii.* However, it was found that *Lates niloticus* and most pascivirous fishes grow, their diets change from mostly invertebrates to almost entirely fish[46]. [46] and [47] indicated that the main preys of the Nile perch, *Lates niloticus,* are *Caridina nilotica*, *Rastrineobola argentea*, anisopteran nymphs, haplochromine species and Nile juveniles fish. The current data confirmed their speculations because the collected fish were of small size (< 1500 g 2181.3) which explain why these fish's guts were filled with invertebrates and smaller fish bones. Large mouth bass, an effective piscivore, can become non-piscivore and maintain sufficient growth rates on alternate prey when small fishes are not available [48]. Their study has shown that juvenile bass and minnows are the preferred prey for largemouth bass, followed by benthic insects, molluscus and large-bodied *Daphnia. Caridina nilotica* is an important food to *L. niloticus* (38.6%) for bottom trawl and 85% in the pelagic trawl; *O. niloticus* (17%) and haplochromine cichlids (64.8%) [49]. Therefore, it can be speculated that in khors of Lake Nasser a wider array of invertebrates was consumed due to natural fish predation. Also these eaten invertebrates can cause a more consistent decrease in the algal densities than grazing by tilapias alone.

In conclusion, the epiphytic microalgae were an important component of the invertebrates and vertebrates production. A wider array of invertebrates was consumed due to natural fish predation. Therefore invertebrates grazers have been recognized as important components in the transfer of organic matter from plant to secondary consumers and numerically dominant species are generally viewed as the main contributors of this energy transfer.

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