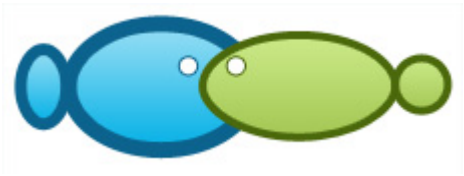

Feeding habits of *Cyprinus carpio* in Foum El-Khanga Dam, Souk-Ahras, Algeria

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Abstract. The knowledge on fish feeding in natural milieu is considered as a necessary step in understanding the biological and the ecological features of the fish species. Therefore, the present study aimed to provide quantitative and qualitative data of the feeding habits of *Cyprinus carpio* in Foum El-Khanga dam (Souk-Ahras, Algeria) during an annual cycle from Mach 2015 to February 2016. The stomach of 347 specimens was analyzed function of the year, seasons of sampling and the sexes of fish. In order to determine the diet of the studied species, the vacuity index (%VI), numerical abundance (N%), frequency of occurrence (F%), and the index of relative importance (IRI) were studied. Among the total examined stomachs, 195 contained preys, and 152 were obviously empty and corresponding to the coefficient of an average annual vacuity index of 43.80%. The monthly fluctuation has evidenced a seasonal diet rhythm, presenting maximal values in spring, characterized by slowing down the trophic activity. The qualitative analysis of the digestive contents has evidenced a diversified regimen diet with 3,051 counted payers. Different eight groups were identified (crustaceans, phytoplankton, fish, nematodes, insects, mud, plants debris and unidentified). This analysis reveals that *C. carpio* of Foum El-Khanga dam is an omnivore species mainly feeds on crustaceans (copepods), and alternatively on phytoplankton (algae). The diet of this species varies function of season and sexes. The ingested proportion of crustaceans was found higher in males than in females. Though, the digital fluctuations of the ingested preys by *C. carpio,* along with the statistical comparison using the Spearman correlation coefficient have showed a homogeneous diet during the four seasons of sampling and between the two sexes.

Key Words: common carp, diet, Spearman correlation coefficient (rho), omnivore, trophic activity.

Introduction. *Cyprinus carpio* (Linnaeus 1758) is considered as the first fish species, artificially widely spread by humans, since its introduction by the Romans from the River Danube throughout Europe (Balon 1995). The species is known as the third most frequently introduced world-wide species (Welcomme 1992), inhabit in still or slowly flowing waters, lakes, reservoirs and permanent wetlands, commonly with silt bottoms (Kottelat & Freyhof 2007). *C. carpio* species has a remarkable tolerance to the varying environmental conditions, and hence it provides a wide species distribution and effective introductions (Forester & Lawrence 1978).

In Algeria, the first description of *C. carpio* has considered the species as a new, even it was introduced in Algeria between the period of 1858 and 1931 (Dieuzeide & Rolland 1951; Kottelat 1997; Kara 2012). Also, it is one of the most commercially important and widely cultivated freshwater fish in the world (Biro 1995; Zhou et al 2003). In aquaculture, this species ranked in 2010 third in terms of worldwide finfish aquaculture production, contributing 9% of the world's total finfish aquaculture production, since Asia accounted for more than 90% and, China alone contributed 77% (2.462.346 tons) of the world's aquaculture production of common carp (3.216.203 tons) in 2009 (FAO 2012).

The description of *C. carpio* diet was well documented by many authors around the world, such as those in France (Crivelli 1981), Spain (Blanco et al 2003), Turkey (Ali et al 2010), Ethiopia (Dadebo et al 2015) and India (Shafi et al 2012; Shukla & Patel

2013; Naik et al 2015). In Algeria, the diet of *C. carpio* was reported in some previous studies, including for example those of Hadou-Sanoun et al (2013) in keddara Dam, and Brahmia (2016) in Oubeira Lake.

Dadebo et al (2015) has evidenced that this species feeds on detritus, insects, macrophytes, phytoplankton, ostracods, zooplankton, and gastropods in Ethiopia. Also, Crivelli (1981) has described the diet of this species in France, and reported that benthic insects, crustacea and detritus are the main prey. Mustafizur et al (2010) found remarkable differences in the feeding condition of *C. carpio* depending to its diet and seasonal feeding activities. Moreover, Ali et al (2010) have reported that this variation in the types of organisms consumed is likely due to the location changes of the species in certain periods for feeding purposes.

Interestingly, the feeding habits of fish are a valuable tool to understand the mechanism and processes that affect the structure of fish assemblages (Kotrshall & Thomson 1986). This provides not only the predatory activity of these species, but also an explanation of the growth variations, the studied behavior, as well as the food intake, the migrations, and even some of breeding aspects (Rosecchi & Nouaze 1987). Indeed, the feeding regime analysis could explain the phenomenon of inter-and intra- specific competitions (De Pirro et al 1999).

To our knowledge, we are the first to describe the diet of *C. carpio* in Foum El-Khanga Dam, Souk-Ahras (Algeria), focusing on the variations function of sexes and season. The study provides the first completed research on the composition and variations of the diet of *C. carpio*, and gives important information on the biology of the studied area.

Material and Method. Fisheries data of this study obtained from the Foum El-Khanga dam were collected in 1994, in a surface area of 1,735 km, and diameter of 190 Km (36°04.344' N/ 007°26.351'E). The study area is located in the north-east part of Algeria, between regions of Sedrata and Ksar Sbahi (nearly 20 Km from side to another). Also, it includes the neighboring region of three cities ("wilayas"): Souk-Ahras, Guelma and Oum El-Bouaghi, seven towns (diaras), and sixteen municipals.

Field sampling and laboratory work. A total of 347 fresh fish samples were collected from the Dam monthly between March 2015 and February 2016. Biological data were transferred to the laboratory on the day of collection to measure the total length (TL) to the nearest centimeter (cm). The sexes were identified by macroscopic observation of the gonads, as previously described by Bagenal & Tesch (1978). Noteworthy, the male gonads (testes) are whitish and smooth, since female gonads (ovaries) are grainy and color ranging from pale yellow to orange (Morsi et al 2015).

The fresh state of stomach of each fish was removed and stored in a pill-box containing formaldehyde of 5%. Each stomach was longitudinally divided, and subsequently its content was emptied in Petri dishes. The ingested preys have been identified to the lowest possible taxonomic level and enumerated under a binocular microscope. The taxonomic identification of the different food items was performed using the reference guide of Moisan (2010).

Data analysis. The feeding regime of *C. carpio* was studied in qualitative and quantitative viewpoint (Hynes 1950; Hureau 1970; Hyslop 1980; Hashim et al 2017).
The following indices were used to quantify the importance of different prey items in the diets of *C. carpio*:

- %VI = Vacuity index

= (number of vacuity stomachs) / (total number of stomachs) × 100.

- %F = Percentage frequency of occurrence

= (number of stomachs containing prey i /number of full stomachs) × 100.

- %N = Percentage numeric abundance

= (number of individuals of prey i / total number of prey) × 100

- index of relative importance (IRI)

The importance of every prey item in the composition of diet is expressed by the index of relative importance (IRI):

$$IRI = \%N \times \%F$$

The IRI index was expressed as:

$$\%IRI = (IRI / \Sigma IRI) \times 100.$$

This index provides more accurate interpretation of feeding habits, minimizing the skews caused by each of these percentages (Boughamou et al 2016). In the present study, IRI would be used without taking into account the weight of preys (Morote et al 2010).

The composition and variations in the diet of *C. carpio* were also compared according to sexes and seasons. The statistical significance of these changes was evaluated by the Spearman rank (rho) correlation coefficient (rho) (Fritz 1974), applied over the ranks occupied by the different prey.

$$rho = 1.0 - \frac{6\sum d^2}{n^3 - n}$$

Where n: is the number of items or categories of ingested prey, and d is the difference between ranks.

Statistical significance is known through the distribution of Student's t at n-2 degrees of freedom (Dagnelie 1975):

$$t - test = \left| \frac{rho}{\sqrt{1 - rho^2}} \right| . \sqrt{n-2}$$

All the statistical analyses were carried out using the STATISTICA (version 8.0) data analysis software system.

Results

Overall analysis of the diet. Monthly variations of vacuity index (VI%) of *C. carpio* are shown in Figure 1.

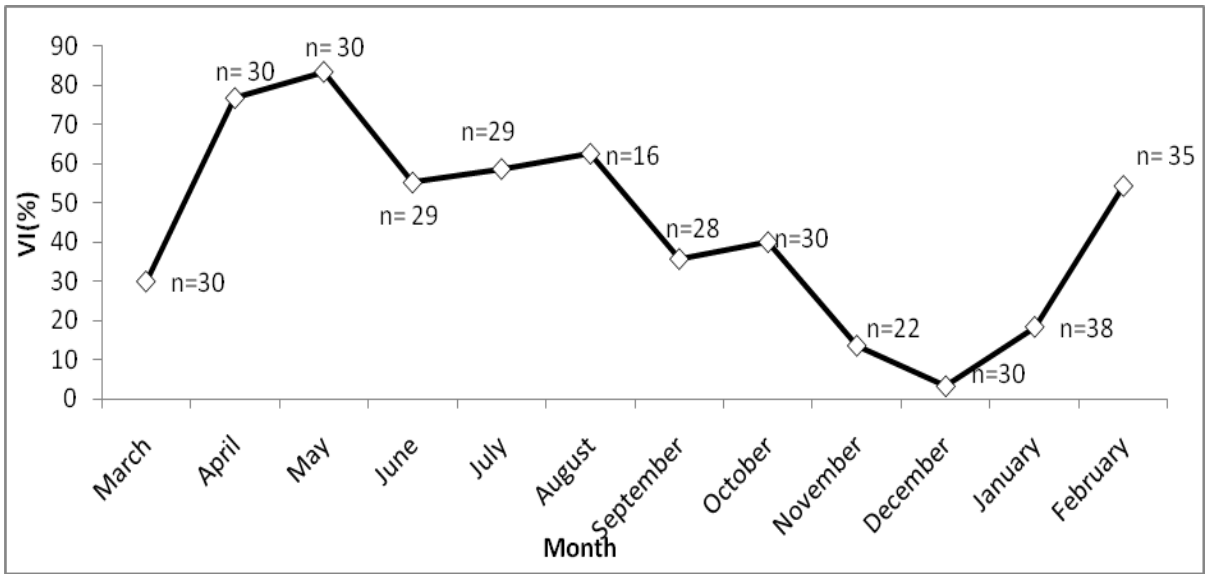

Figure 1. Monthly variations of vacuity index (VI%) of *C. carpio*; n - number of stomachs examined, between March 2015 and February 2016.

Among the 347 examined stomachs, 152 were empty, corresponding to average annual stomach vacuity index of 43.80%. Though, a minimal value of 30% in March quickly increases to reach its maximal value of 83.33% in May, and thus the vacuity suddenly goes down in June to reach a value of 55.17%. A new increase tendency was noticed

from July (VI = 58.62%), and continued till august (VI = 62.5%), before being dropped in September (VI = 35.71%). The vacuity increases in October (VI = 40%), and subsequently it sharply drops in December for reaching a value of 3.33%, in order to reflect a new increase tendency till February, where it reaches the value of 54.29% (Figure 1).

Further, the 195 fall examined stomachs of *C. carpio* of Foum El-Khanga Dam, have promoted to identify 3,051 preys. Table 1 reports overall results of the diet composition and classification of prey of *C. carpio* in the Foum El-Khanga Dam. The qualitative analysis of different stomachs leads to identify eight major groups, which are: crustaceans (copepods, cladocerans), nematodes, phytoplanktons (algae), fish, dipterans, plants debris, mud and unidentified (Table 1).

Table 1

Feeding composition and classification of prey according to the %IRI importance of *Cyprinus carpio* in Foum El-Khanga Dam (Souk-Ahras, Algeria)

	Prey item	*%N*	*%F*	*IRI*	*%IRI*
Crustacea		59.59	60.51	3605.7909	51.19
	Copepods	43.99	32.3	1420.877	20.17
	Cladocerans	15.6	28.2	439.92	6.25
Phytoplankton	Algue	18.52	67.18	1244.1736	17.66
Insecta	Diptera	10.65	12.82	136.533	1.94
Vertebrata	Fish	0.36	4.62	1.6632	0.02
Unidentified		6.06	27.69	167.8014	2.38
Plants d		0.85	5.13	4.3605	0.06
Detritus		3.54	6.15	21.771	0.31
Nematoda		0.43	3.08	1.3244	0.02

Plant d - plant debris; %N - Numerical abundance; %F - frequency of occurrence; %IRI - index of relative importance.

As shown in Table 1, crustaceans are the most important food items in the diet of *C. carpio*, followed by phytoplanktons (algae). Additionally, the crustaceans are composed a number of 59.59% and an occurrence of 60.51% of the total food items. Crustaceans were represented by copepods and cladocerans. While, copepods are the main crustacean food items, before the cladocerans, since phytoplanktons are the second class in the total food items as expressed by number and occurrence, respectively, 18.52% and 67.18%. According to the index of relative importance (IRI), crustaceans are the preferable food item, exhibiting about 51.19%, followed by phytoplanktons (algae), then unidentified and dipterans representing, respectively, 17.66%, 2.38% and 1.94%. The other category of the total food items are consumed in negligible quantities with values of the IRI% generally less than 1, meanwhile the lowest value was recorded for nematodes and fish (Table 1).

Seasonal variations in the diet. Function of seasons (Figure 2), the coefficient of stomach vacuity index shows a maximal value in spring (VI = 63.33%), then a gradually decrease to reach its minimal value in winter (VI = 26.21). The obtained samples during the period of summer and autumn showed that, the percentages of stomach vacuity index are, 58.11% and 31.25% respectively.

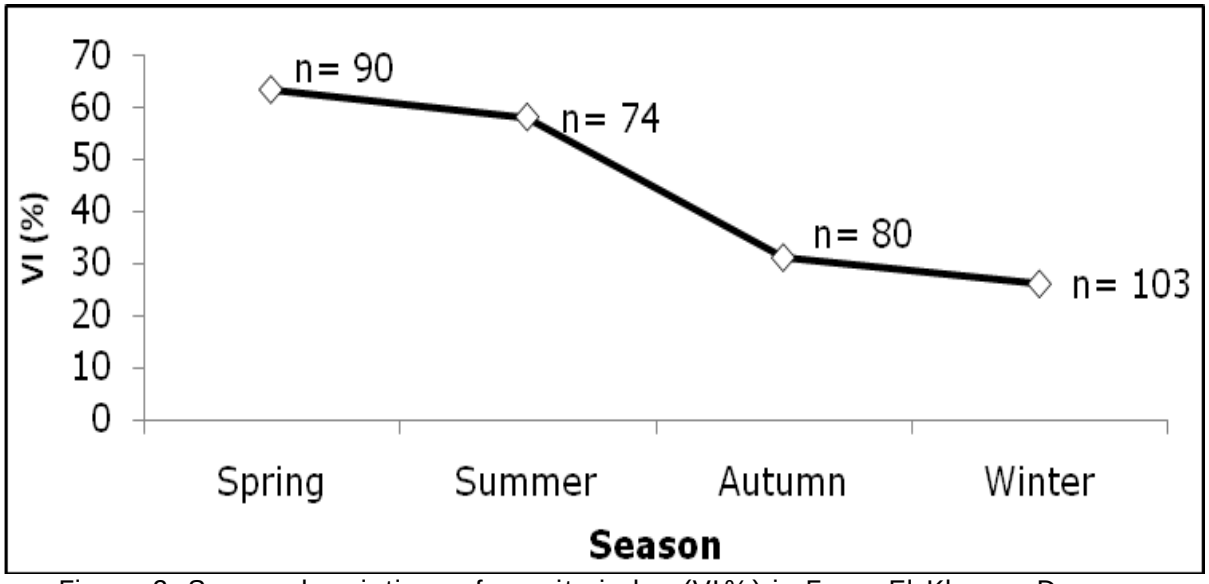

Figure 2. Seasonal variations of vacuity index (VI%) in Foum El-Khanga Dam; n - number of stomachs examined per season, from March 2015 to February 2016.

Seasonal variations of the different food items, index of relative importance (%IRI) of the food items are shown in Table 2. Crustaceans revealed high values of index of relative importance (IRI) during summer and autumn, showing the percentages 70.91% and 78.84%, respectively, since the low values were recorded during spring and winter with percentages of 50.34% and 68.9%, respectively.

Phytoplanktons, insects and unidentified items were recorded during all seasons, but fish and debris of plants were observed only during spring and summer; however, they were absent during autumn and winter. On the other hand, detritus and nematodes were recorded in all seasons, but detritus and nematodes were not seen in winter, and autumn respectively. Phytoplankton was the secondary prey in autumn (IRI% = 19.04) and winter (IRI% = 27.3); meanwhile insects were the secondary prey in summer (IRI % = 17.52), whereas insects were the secondary prey with phytoplankton in spring. According to Spearman rank (rho) correlation coefficient, the diet composition between seasons was significantly correlated (Table 3).

Table 2

Seasonal variations of the relative importance index (IRI%) of the main items

Consumed items	*IRI%*			
	Spring	Summer	Autumn	Winter
Crustacae	50.34	70.91	78.84	68.9
Phytoplankton	27.05	1.56	19.04	27.3
Insecta	10.48	17.52	0.09	1.2
Fish	0.25	0.42	0	0
Unidentified	8.36	6.25	1.81	2.5
Plant d	0.9	0.73	0	0
Detritus	2.54	2.57	0.22	0
Nematoda	0.08	0.04	0	0.1

Plant d - plant debris.

Table 3

Statistical comparison of diet during seasons

Season	*rho*	*t-test*	*significance*
Spring-Summer	0.8571	4.0754	+
Summer-Autumn	0.7619	2.8814	+
Autumn-Winter	0.8333	3.6923	+
Winter-Spring	0.8095	3.3773	+

+: homogenous diets.

Variations in diet according to sexes. Among the 149 examined stomachs of males (21.6 ≤ TL≤ 47.5 cm), 65 were empty (VI = 43.62%), since the 198 female examined stomachs (26.6 ≤ TL ≤ 54.9 cm), 87 were empty (VI = 43.94%).

According to the IRI% index (Table 4), the main prey group category was represented by crustaceans (IRI % = 49.22) and phytoplanktons (IRI % = 37.34) in female diets and by crustaceans (IRI % = 79.7) in male diets. The insects and unidentified are of valuable importance in the female stomachs (IRI % = 6.35 for insects and 6.07 for unidentified) as compared to those of males (IRI % = 1.04 for insects and 1.89 for unidentified items). The other fish consumed items (detritus, plant debris, fish and nematodes) are consumed in negligible quantities in both sexes (Table 4). The Spearman rank (rho) correlation coefficient (rho) confirms the homogeneity of the diet between the two sexes (rho = 0.9345, t-test = 6.4306, $p<0.05$).

Table 4

Variations of the percentage of relative importance index (IRI%) of the main items ingested by *Cyprinus carpio* in Foum El-Khanga Dam, Algeria, according sexes

Consumed items	*%IRI*	*%IRI*
	Females	*Males*
Crustacae	49.22	79.7
Phytoplankton	37.34	17.03
Insects	6.35	1.04
Fish	0.09	0.01
Unidentified	6.07	1.89
Plant d	0.27	0.02
Detritus	0.63	0.29
Nematoda	0.03	0.02

Plant d - plant debris.

Discussion. The coefficient of the annual average of stomach vacuity index of *C. carpio* of Foum El-Khanga dam equals 43.80%, which varies as a function of sexes and seasons of sampling. This value is high, but quite close to that obtained in Oubeira Lake, Algeria (VI = 34.16%) (Brahmia 2016). Hadou-Sanoun et al (2013) provided values ranged from 35.29% to 42.31% in Keddara dam of Algeria. The monthly fluctuations of the coefficient of stomach vacuity index of *C. carpio* have evidenced a seasonal food rhythm. This rhythm is intimately linked to the sexual cycle of the species (Darbal & Kara 2010). The trophic activity of *C. carpio* is highly low in spring of April to May, showing a peak of vacuity coefficient in May (VI = 83.33%). Similarly, Brahmia (2016) has found the highest values of the seasonal vacuity coefficient recorded in spring (VI = 53.33%) in Lake Oubeira, Algeria. Manon & Hossain (2011) reported that the highest percentage of stomach vacuity was in the month of April (VI = 56.67%), however, the increased stomach vacuity from April coincides with the breeding period of this species. As previously reported (Shukla & Patel 2013), the feeding intensity of *C. carpio* is very poor in spawning period. Indeed, the increased gonad weights during springs could repress the digestive tube and reduce the alimentary bolus, and therefore they lead fishes to feed

less (Boet 1980). Moreover, during spawning time, fishes need more energy input, in order to find the breeding needs (Froese & Pauly 2000). The vacuity is minimal in winter (VI = 3.33% in December), which reflects its voracity in cold period and, therefore, confirms the strong intensity of predation of this species. Subsequently the species takes up its food for reaching the highest level in December, where 96.67% of the examined stomachs are full. The taking back of trophic activity promotes fishes to compensate the energetic consumption due to breeding (Darbal et al 2007).

The general composition of regime shows that *C. carpio* has an extended dietary specter, including crustaceans (copepods and cladocerans), phytoplanktons (algae), plants debris, fish, insects (dipterans), mud, nematodes, and unidentified items. These results are in line with those found on *C. carpio* from the Govindgarh Lake, Rewa (India), feeding on zooplanktons, phytoplanktons, aquatic plant parts, debris, detritus and insects (Shukla & Patel 2013). Importantly, the qualitative and quantitative compositions of basic diet of this species vary as a function of the region and the presence or absence of some preys. Manon & Hossain (2011) reported that *C. carpio* feeds on aquatic plant parts (F = 20.12%), phytoplankton (F = 16.46%), zooplankton (F = 19.69%), debris and detritus (F = 22.00%), insects (F = 6.78%) and semi-digested materials (F = 14.83%). Such differences in *C. carpio* feeding habits were related to a number of factors. Of note, changes may be related to physiological changes during the fish's lifecycle (Rahman et al 2009; Kloskowski 2011).

As known, index of relative importance (IRI) is used as an indicator for the preference of food items. The present study revealed that crustaceans are the first preferable food item followed by phytoplanktons. Thus, the presence of crustaceans indicates that *C. carpio* are a bottom feeder. Alike, the results of Jan & Das (1970) and Shafi et al (2012) obtained in different locations concord with our data. Naik et al (2015) also reported that it is commonly emphasized that older *C. carpio* are a bottom feeder. However, the presence of both animal and plant food items in the diet indicates that *C. carpio* is omnivorous, along with preference, pronounced for benthic invertebrate preys. Additionally, *C. carpio* is an omnivorous feeder; however animal origin food was more consumed than plant origin food. Similar feeding habits were reported for this species elsewhere for which data are available (Magalhaes 1993; Blanco et al 2003; Saikia & Das 2008; Dadebo et al 2015; Brahmia 2016). Studies conducted in Arunachal Pradesh (India) showed that the diet of *C. carpio* consisted of algae, zooplankton (Cladocera, Copepoda, Rotifera), benthic organisms, plant residues and mud (Saikia & Das 2008). Furthermore, Magalhaes (1993) have found zooplankton (Cladocera, Copepoda and Rotifera), phytoplankton, detritus and mud in the Iberian stream. Ali et al (2010) studied the food composition of *C. carpio* from the Hirfanli Dam (Turkey), and consequently they confirmed that the species is omnivorous, mainly feeds on zooplankton, phytoplankton and benthic organisms. Alike, the results of Dadebo et al (2015) confirmed that *C. carpio* is omnivorous in its diet in Lake Koka (Ethiopia), and consumed a wide range of food items, including detritus, insects, macrophytes, phytoplankton, ostracods, zooplanktons, and gastropods. Whilst, the study of Brahmia (2016) on Oubeira Lake (Algeria) showed that specimens consumed mainly mud (F = 32%), but expanded their diet (in order of importance), crustaceans (F = 29.8%), fish (F = 25.26%), plants (F = 8.95%) and insects (F = 3.99%). Therefore, these authors confirmed its omnivorous profile.

In Foum El-Khanga dam, the omnivore character has been also observed in both sexes of the *C. carpio*. Noteworthy, this species is omnivore whatever the season of sampling, but with numeric proportions which vary for some items, for instance, the case of crustaceans, phytoplankton and insects. The disparities in values of index percentage that fluctuate in time would be related to the availability of different preys, as well as to their abundance in the natural milieu (Karachle & Stergiou 2008).

According to Spearman rank (rho) correlation coefficient, the diet composition was homogenous between season and sexes. Also, the crustaceans were to be the main diet components for male and female individuals. The study of nutritional specter variations of *C. carpio* as a function of season shows that the nature and the importance of the ingested preys vary as a function of seasons, usually with respect to the important relative predominance for crustaceans, which include the phytoplankton during the all

seasons, except the summer within which the insects proportions become higher than phytoplankton. This is justified by the fact that the occurrence frequency, the abundance index and index of relative importance (IRI) of crustaceans are highly increased, exhibiting therefore the importance of this category of preys in the diet of *C. carpio*. The importance of zooplankton in the diet of older *C. carpio* has been highlighted in many studies (Adamek et al 2003; Khan 2003). Similarly, we can therefore divide the various taxons in two groups: one prey group which is usually present in the stomach contents during the all seasons whose relative abundance is generally important, since the second group whose presence in the stomach contents is limited for two seasons (spring and summer). Here, the relative abundance of preys becomes inferior to 2%. Nevertheless, it is necessary to note the absence of some taxons during some seasons, such as fish, plants debris, nematodes and mud, during the seasons of autumn and winter, unlike to two other seasons. This variation is resulted from the composition of food organisms changes occurred during the yearly seasons (Bhuiyan et al 1999). As previously reported many factors can affect the diet of *C. carpio*, however, including age and weight, natural food resource availability, season, etc (Rahman et al 2009; Kloskowski 2011). In Dal Lake of Kashmir Valley (India), Naik et al (2015) showed that the detritus (43.50%) are abundant preys during any season. Also, the author reported that among the animal food, crustaceans were present throughout the year with maximum and minimum contributions in May (19.9%) and December (4.2%) respectively. In fact, the diet of *C. carpio* has seasonal variations, attributing to its location changes in certain periods for feeding purposes (Ali et al 2010).

Conclusions. This study highlights the following points:

- Among the basic diet composition, 3,051 prey items were identified.
- The coefficient of average stomach vacuity is quite high (VI = 43.80%), the maximal and the minimal values of IV have been, respectively, recorded in spring and winter.
- The predator feeding habit following a seasonal rhythm.
- The results shown that the most important food categories of *C. carpio* in Foum El-Khanga Dam were crustaceans and phytoplankton.
- Foods of minor importance were insects, fish, nematodes, mud, unidentified and plants debris.
- The crustaceans are preferential preys regardless of sexes and seasons.
- The statistical comparison using Spearmen rank correlation coefficient (rho) showed no change in the diet as a function of time and between sexes.
- *C. carpio* of Foum El-Khanga dam Souk-Ahras (Algeria) is an omnivorous feeder.

Conclusively, the present study provided a valuable knowledge about the biological and ecological aspects, as well as the development of conservation measures of this species studying its dietary regime.

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