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Environmental parameters and parasitism in common carp (*Cyprinus carpio* Linnaeus, 1758) caught from Oubeira Lake (North-East of Algeria)

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ABSTRACT

This study pertains to biometry and parasitism of the common carp captured in Lake Oubeira. This involved collection of 360 carp specime which were weighed and measured before being dissected to harvest the parasites. The size of the carp in Lake Oubeira varied from 11 to 51 in length, although more than 70% did not exceed 31cm in length. This fraction of the studied population exhibited isometric growth, wit condition factor that did not exceed 1.15.The application of the Von Bertalanffy equation shows that Carps of Lake Oubeira have an asympto length of 55.65 cm and a maximum length of 53cm with a growth rate of about 0.22 year $^{-1}$. The Observation of anatomical morphologi characters of 869 parasites collected allowed us to identify a Monogenea (*Dactylogyrus anchoratus*) a Crustacea (*Argulus foliaceus*), t tapeworms (*Bothriocephalus acheilognathi* and the larval form of *Ligula intestinalis*) and nematode (larvae *Contracaecum sp.*). The latte reported for the first time in the general cavity of *C. carpio* originating from Oubeira Lake. The Survey of the evolutionary dynamic parasitism reveals that *Contracaecum sp* present throughout the year; and affects over 30% of carp. The Statistical analysis showed that distribution of parasites is related to the season and the fish size. The use of principal component analysis shows that water temperature correlated positively with the distribution of *contracaecum sp*, *D. anchoratus* and *A.foliaceus*. These parasites were more frequents in sum and autumn when water temperature and suspended material present the highest values, in contrary; water temperature is correlated negativ with the distribution of *B.acheilognathi* and *L.intestinalis*. It appears from this study that the water temperature has a great influence distribution of parasites.

Key words: *C. carpio*; Lake oubeira; isometric growth; North east of Algeria; dynamic

INTRODUCTION

The common carp is a freshwater fish that shows a wide distribution in the world [71]. Its natural range extends from the Aral Sea to China and the Amur basin [60]. This global distribution of carp is related to the many introductions around the world to promote the cultivation, aquaculture and sport fishing [36,25,11].

Algeria, like many other countries of the world was affected by the political introductions of new species of fish. The aims of some introductions of fish species includes occupying vacant ecological niches or stocking of watersheds that are deprived of fish (e.g. dams, reservoirs). Introduction of a species, however, also entails introduction of its parasites and associated bacteria [59,24,48,14], doing so can hence result in a range of ecological effects.

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In addition to giving rise to problems relating to pathologies [48], introduction of the Chinese carp in Lake Oubeira has resulted in the elimination of a large portion of the aquatic vegetation, as well as a decrease in the autochthonous populations and waterfowl [46].

Villizi *et al*., [66] report, in common carp inhabit various water in Turkey, the existence of 41 species parasites. Carp is nevertheless likely to be carrier of viruses, bacteria, fungi and parasites [26]. The parasites are causing major problems in fish farms or natural stocks of fish; this is why freshwater fish parasites continue to be the subject of numerous studies [27]. Tombi and Bilong-bilong [65] Tekin-Özan *et al*., [64]; Loucif *et al.*, [44]; Fomena *et al.*, [29]; Borji *et al.*, [16]; Nematollahi *et al.*, [53]. In Algeria, the studies of parasites of Cyprinidae are few [49,50,34,22,17,3]. The aim of this study is firstly,to determine the structure carp's population, secondly to identify the influence of some environmental factors on the epidemiological parameters(prevalence, intensity of infestation and abundance) of the parasites.

MATERIALS AND METHODS

Lake Oubeira is a fresh water lake, situated in Algeria North-East (N36°50, E08°23) (Fig.1). It covers a surface area of 2,200 hectares, and that has a maximal depth of 4m. It is a designated wilderness area (registered with the RAMSAR Convention) of the Parc National d'El Kala that has the unique distinction of hosting the most important wetland complex of the Maghreb area [18]. The native Ichthyofauna of the Lake Oubeira is represented by *Barbus callensis, Pseudophoxinus callensis, P.guichenoti, P.punicus* and Gambusia *affinis affinis* (Poeciliidae), *Mugil cephalus, Liza ramada* (Mugilidae) and eel *Anguilla anguilla* [52].

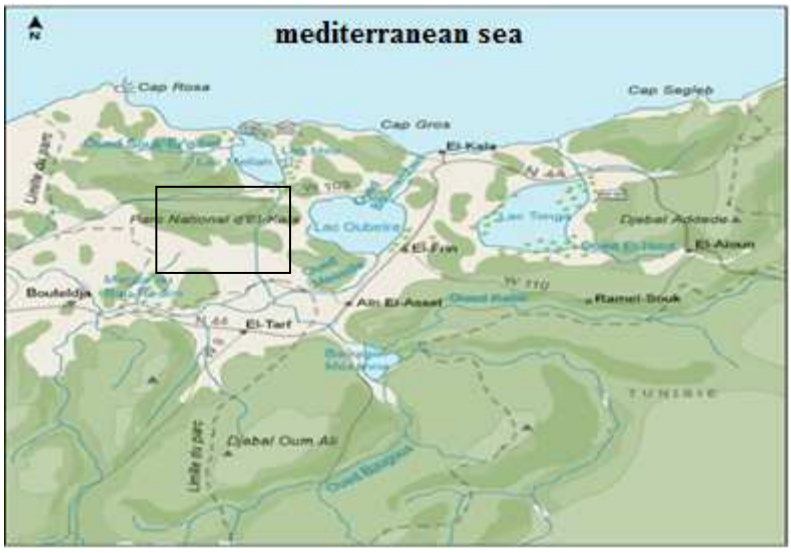


Fig. 1: Study area

The temperature and dissolved oxygen in the water is measured, monthly, using a multi parameter sensor provided (brand Consort 335); as regards their suspended material is estimated using the differential weighing method [4].

A total of 360 carps (30 specimens per month) were collected between January 2012 and December 2012, by professional fishermen, and then transported live on ice to the laboratory where they were measured (total length, to the nearest centimeter) and weighted weigh with a balance. Fish gills were cut out and examined under a microscope. Vigorously, moving worms were separated from the gills and fixed in70 % alcohol and carefully examined under stereo microscope (Olympus SZX 10). The carps were opened by a longitudinal incision along the belly. The intestinal tract was cut at each end and lifted out to reveal the parasites. The parasites were then washed and fixed in 70 % alcohol.

The nomenclature adopted in reporting the prevalence the mean intensity and abundance is that customarily used [20].

Linear growth: The growth parameters were determined by the FISAT II software; Asymptotic length $L\infty$ and K growth rate of the Von Bertalanffy equation [67] were estimated through d`ELEFEN 1, the linear growth law is expressed by the equation: $Lt = L\infty (1\text{-}e^{K (t\text{-}t0)})$ Lt: length at time t (cm), $L \infty$: asymptotic length (cm), K: growth coefficient ($year^{-1}$), t0: age hypothetical theory to zero length.

Relative growth: (length-weight relationship): The length and weight of fish are highly correlated. The relationship between the size and weight of a fish is reflected in the type of formula ($W = a \times L_T^b$); W:

eviscerated weight (g), L_T: total length (cm) a: constant, b: coefficient of allometry. The type of growth is determined according to b (b = 3: isometric growth between weight and length; b <3: negative allometry b> 3 positive allometry).

Condition factor (k): This coefficient is calculated using the following formula: $K = (W / L_T^b \times 100)$; W: eviscerated weight (g), L_T: total length in cm, b: coefficient of allometry considered equal to 3.

Statistical Analysis:

Statistical analysis of the data was performed under R (R Development Core Team, 2014 Version 3.1.2) developed by Ross Ihaka (1996). The normality condition of the distributions was checked beforehand by applying the Shapiro-Wilk (not shown). Distributions, being usually of asymmetric time, forced us to choose non-parametric alternatives for the statistical analysis.

The correlations between the sets of parameters are evaluated by the non-parametric Spearman correlation coefficient (r) to analyze the intensity of relations between our parameters. Furthermore, comparisons of intensity and the abundance of parasite were performed using the nonparametric test exact of Fisher. Principal component analysis (PCA) was carried out using the package FactoMineR [37] on the normalized data. The principal component analysis (PCA) was used as a descriptive and exploratory method aiming to characterize, through a multivariate approach, the structuring of our inter-months variations and to highlightthe contribution of environmental parameters measured on prevalence, mean intensity and abundance of parasites. All packages used were downloaded from the official website of CRAN (The Comprehensive R Archive Network): http://cran.r-project.org/web/packages/. Tables and graphs were drew by Excel software.

Results:

Proportions of size classes:

Over the course of 12 months we captured 360 carps, ranging in size from 11cm to 51cm (Fig.2)

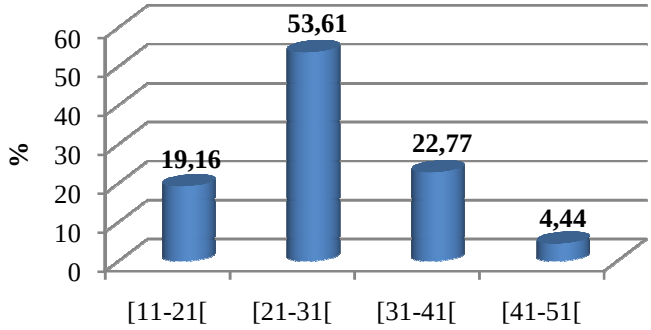


Fig. 2: Size distribution for carps captured

Linear growth:

The application of the Von Bertalanffy equation shows us that the carp of Lake Oubeira have an asymptotic length of 55.65 cm and a maximum length of 53cm with a growth rate of about 0.22 year^{-1}**.**

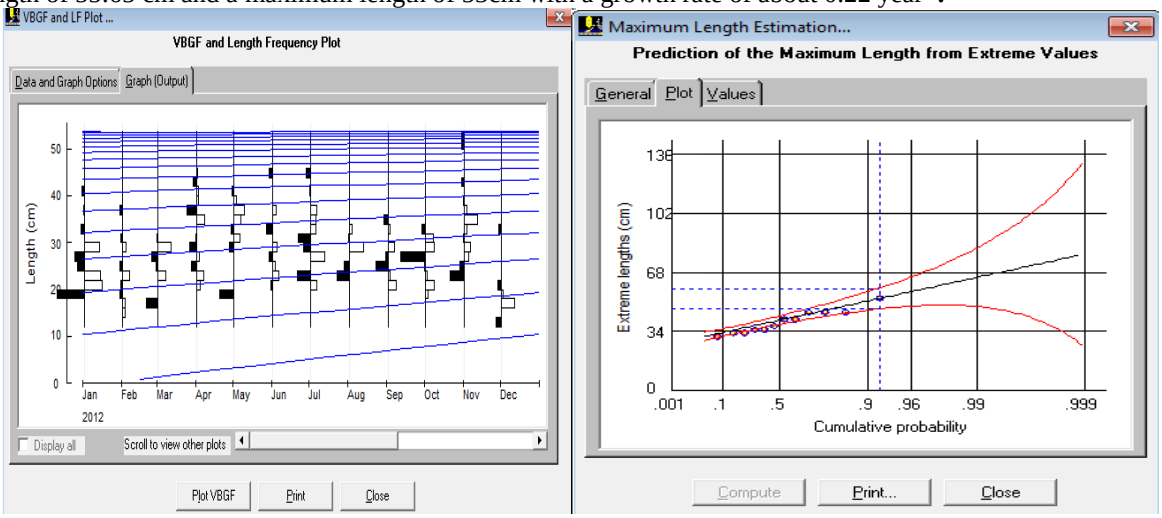


Fig. 3: Frequency distribution of length and maximum length in *C.carpio*.

Relative growth: The estimated relative growth, by the equation relating the total length with eviscerated weight, shows the existence of an isometry of growth with a correlation coefficient r = 0.929.

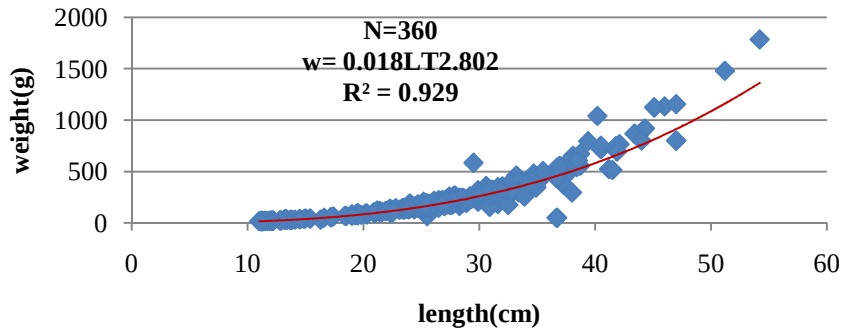


Fig. 4: length-weight relationship in carp of Lake Oubeira.

Coefficient of Condition (K): Condition factor of Carp from Lake Oubeira varies between 0.93 and 1.15; the highest value is recorded in winter (1.15) (Fig. 5) and the lowest value is recorded in the summer.

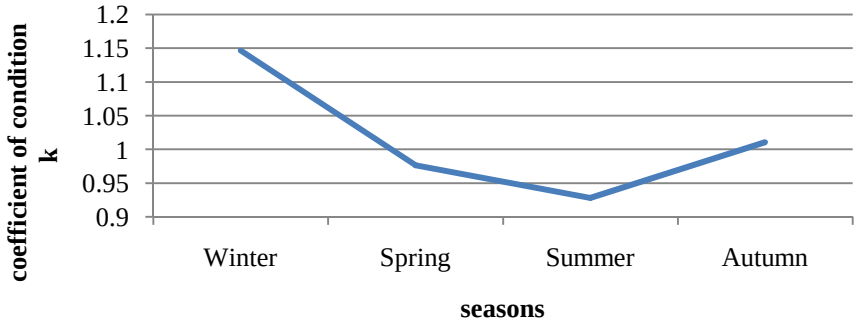


Fig. 5: Seasonal variations in condition factor (k) of carp.

Parasitism:

The examination of 360 specimens of *C.carpio* originating from Oubeira lake revealed the presence of 869 parasites attached to 5 families: Dactylogyridae (*Dactylogyrus anchoratus*), Argulidae (*Argulus foliaceus)*, Bothriocephallidae (*Bothriocephalus acheilognathi)*, Diphyllobothriidae(plerocercoid larvae of *Ligula intestinalis*) and Anisakidae (*Contracaecum sp* larvae).

Table 1: epidemiological parameters

	Dactylogyrus anchoratus	*Argulus foliaceus*	*Contracaecumsp*	*Bothriocephalus acheilognathi*	*Ligula intestinalis*
P%	12,5%	1,66%	30,55	3,33%	0,83%
I	3,77	1,16	5,75	4,66	1
A	0,47	0,01	1,75	0,15	0,008

(P%: Prevalence, I: intensity, A: abundance)

From Table 1it is the nematode *Contracaecum sp* that affects over 30% of carp, against only 12% and 3% for *Dactylogyrus anchoratus* and *Bothriocephalus acheilognathi* respectively. The other 2 species of parasites infest less than 2% of fish numbers. The intensities of infestations are on the order of 5.75, 4.66 and 3.77 for *Contracaecumsp*, *Bothriocephalus acheilognathi* and *Dactylogyrusanchoratus* respectively. This is *Contracaecum sp* is the most abundant (1.75 individual / fish examined) and comes with *Dactylogyrus anchoratus* (0.47 individual / fish examined).

Table 2: Seasonal distribution of parasites found on *C. carpio* in Lake oubeira

Species	Winter	Spring	Summer	Autumn
Dactylogyrusanchoratus(170 specimens)	4	17	128	21
Argulusfoliaceus (7 specimens)	0	0	4	3
Contracaecumsp. (633 specimens)	88	195	200	150
Bothriocephalusacheilognathi	53	1	2	0

(56 specimens)				
Ligulaintestinalis (3 specimens)	3	0	0	0
Total (869 specimens)	148	213	334	174

Results obtained revealed that *Contracaecum sp* and *Dactylogyrus anchoratus* are present throughout the year; the percentage of parasitic individuals is 92.4%.

Percentage of the individuals *Contracaecumsp* living in the body cavity is also higher in summer and spring. It is reported that the percentage of the individuals of *D. anchoratus* and *A. foliaceus* in the gills is higher in dry season; as to *B. acheilognathi* and *L. intestinalis* are present just for winter. (Tab2).

The Fisher test shows a distribution of dependence df = 3, p-value <2.2e-16, the test is significant that is to say that distribution of parasites depends on the season.

Distribution of parasites depending on class size:

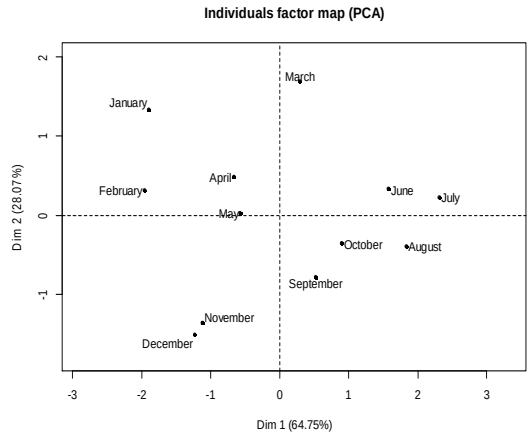
Table 3: Distribution of parasites as a function of the size of carps

Parasites	[11-21[	[21 - 31[	[31 - 41[	[41 - 51[
Dactylogyrus anchoratus	5	6	118	41
Argulus Foliaceus	0	7	0	0
*Contracaecum*sp.	12	372	205	44
Bothriocephalus acheilognathi	53	2	1	0
Ligula intestinalis	3	0	0	0

The parasitic *Contracaecum* sp. and *D. anchoratus* species are encountered in the four size categories that comprise the carp population of Lake Oubeira. However, individuals in the [21 – 31cm] and the [31 – 41cm] size categories harbored the greatest number of specimens of the *Contracaecum* sp. species. In regard to *D. anchoratus*, it is particularly the individuals in the [31 – 41cm] size category that harbored the highest proportion of this parasite (i.e. in 69.4%). While the *B. acheilognathi* parasite was not encountered in carp belonging to the large size category (i.e. [41 – 51cm]), by contrast it was found to be highly prevalent (i.e. in 94.6%) in the small-sized carp (i.e. [11 – 21cm]. The presence of *Argulus foliaceus* and *Ligula intestinalis* parasites was limited to individuals belonging to the [21 – 31cm] and the [11 – 21cm] size categories, respectively.

The Fisher test shows a distribution with df = 6 dependency, p-value <2.2e-16; the test is significant that is to say that the distribution of parasites depends on the class size.

Principal component analysis (PCA):



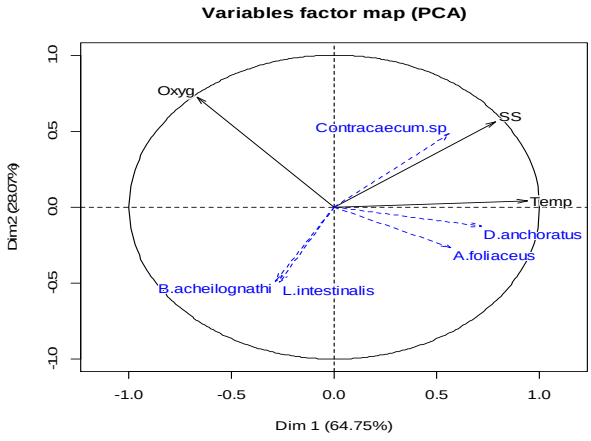


Fig. 6: Projection of months on the first two principal axes. **Fig. 7:** Correlation circle of biotic and abiotic variables with the first two principal axes.

The use of principal component analysis (PCA) as a preliminary and exploratory descriptive approach helped visualizing the structure of the temporal variation in Lake Oubeira according to five measured variables: water temperature, pH, dissolved Oxygen, suspended solids content and distribution of parasites.

PCA also led to investigate the existence of possible similarities between different months and distribution of parasites. It is noteworthy that the distribution of parasites was used as an additional quantitative variable to

achieve the PCA by the Facto MineR package. Moreover, PCA was performed on the reduced-centric data (standard PCA), whose results are summarized in figures (6 and 7).

The first two major components (F1 et F2) contain 86.73% of total variability (64,75 % and 28,07 % respectively).

Axis 1 is defined to the positive pole by water temperature and suspended material with strong relative contribution(r= 0,93 ; cos^2 =0,88 et r= 0,78 ; cos^2=0,61 respectively), and it is the warmest months (june, july, august, september and october) that result in the most pronounced effect The increase in temperature and suspended material favorite the appearance of parasites *D. anchoratus*, *A.foliaceus* and *Contracaecum* sp, these parasites were more frequents in dry and fall season.

Axis 2 is defined to the positive pole by dissolved Oxygen(r=-0,66 ;cos^2=0,44),on this Axis are project the cold months (january, february, november and decembre) and *B. acheilognathi* and *L.intestinalis.* So we can say that the decrease in temperature favors oxygenation of water and abundance of parasites *B. acheilognathi* and *Ligula intestinalis.* These parasites were more frequents in wet period.

Discussion:

Of the 360 carps captured during the study period (January to December 2012), ranged from 11cm to 51cm, with a high proportion of the carps falling into the 21- 41cm size range. The application of von Bertalanffy growth equation shows that the carp populations have an asymptotic length of 55.65 cm and a maximum length of 53cm with a growth rate of about 0.22 $year^{-1}$. In Turkey, Balik *et al.*, [10], report that this species reaches an asymptotic length equal to 130cm with a growth rate of around 0,75 $year^{-1}$.

The length-weight relationship of the carp population in the Lake oubeira was $W=0.018*L_T^{2,802}$. The value of the length-weight relationship showed that body weight grows isometrically with length. The length-weight relationship of carp population for the dam Ghrib in Algeria [5] and for the Caspian sea in Iran [63], presents a positive allometric growth; these variations could be attributed to differences in age, maturity and sex, geographic location and associated environmental conditions, such as seasonality, stomach fullness, disease and parasite loads [8].

The mean condition factor of the population was calculated as1, 01; the mean condition factor of carp population in the Lake Karamik (Turkey) as 2.022 [10], It is clear that the mean condition factor of the carp population in the lake oubeira is lower than that of carp population in Turkey. The reason may largely be attributed to feeding opportunities.

In terms of the gills, we observed a predominance of the monogenic *D. anchoratus* over the *A. foliaceus* crustacean. The predominance would be related not only to abiotic parameters such as temperature and salinity but also interspecific competition for the ecological niche; because according to Mackenzie and Ball [45], the competition could be the cause of this dynamic between the different groups that some ecological factors favor one group over another.

Meddour [49], report the presence of three species of monogenea: *D. extensus*, *D. anchoratus* and *Gyrodactylus sp* in the gills of *C. carpio* caught from Lake oubeira. On the same species from foum El Khanga dam (Souk Ahras) Allalgua *et al*., [3] report the presence of 5 species of monogenea among which 4 are attached to the genus *Dactylogyrus.* Chaibi [22] report on the gills of *C. carpio* originating from Timgad dam (Algeria), the presence of two species of monogenea *Dactylogyrus sp* and *Gyrodactylus sp*.

The presence of *D. anchoratus* in *C. carpio* is reported in Turkey [56,43], in Kurdistan Iraq [1], in Northeast of Iran [16] and in Latvia [41], this parasite was found for other species such as the *C. auratus* and *L. Barbus esocinus* [1] and the *Auratus auratus* from Bulgaria [15].

In Lake Oubeira, *D. anchoratus* is highly abundant during the summer. Our results are bolstered by those of Borji *et al*., [16] who showed that infestation by *D. anchoratus* is higher in summer time for the *C. carpio* populating Lake Mashhad in Iran.On the other hand, Allalgua *et al*., [3] have reported the various species encountered in the *C. carpio* of Foum El Khanga appeared in different seasons, hence suggesting that infestation correlates with changes in temperature.

A. foliaceus, is reported in *C. carpio* captured in river Bounamoussa and Lake Oubeira [49], but In *C. carpio* of Foum El Khanga [17] and of Timgad dam [22] the presence of *Argulus foliaceus* is not reported. This variability in the parasitic abundance is a function of the ecology of the host [51,73], the phylogeny of the host and the parasite [20,62], the water quality [30] and the testing methods [69].

For the Lake Oubeira carp, the 7 specimens of the *Argulus foliaceus* species were collected in summer time and the autumn. Numerous authors have reported regarding the influence of temperature on infestation by *Argulus* species [35,69,70]. In the Czech Republic, Rohlenova *et al.*, [61] have reported that infestation of the *C. carpio* population in the Vodňany fish farm by the two crustaceans *Argulus foliaceus* and *Ergasilus sieboldi* is higher in spring and summer time.

D. anchoratus is present in all four of the size categories, although it is particularly the individuals in the [31 – 41cm] size category that harbor the greatest proportion of this parasite (at 69.4%). Our results are in agreement with those of Allalgua *et al*., 2015 who report that it is the fish with overall lengths between 37 cm

and 47 cm that are the most infested with parasites. Several investigations indicate that the level of *Dactylogyrus* is often higher in older fish than in younger ones [56,57]. The increase in the parasite infection rate as a function of the size of the host specimen can be explained by the increase in gill surface area with body length [33,13,9,21]. According to these authors, larger-sized fish provide a larger gill surface area that can hence accommodate greater numbers of parasites. Further, the time of exposure of the fish gills to infestation by parasites could explain why larger specimens are more infested.

We report for the first time the presence of the larvae of the nematode *Contracaecumsp* in the general cavity of *C. carpio* populating the lake Oubeira. In Iran, the presence of this larva is reported in *Capoeta damascina* (cyprinidae) in Lake Kerman [58] and in *Barbus lacerta* populating the Gheshlagh reservoir [19]. The survey of the evolutionary dynamic of parasitism reveals that *Contracaecum sp* present throughout the year, the highest infestation is recorded during summer and spring. The high prevalence of the larvae of *Contracaecum* sp in the populations of *Mugil cephalus* from Saloum estuaries means that this nematode more frequent in dry season [54]. The study of the parasitism evolution from a consideration of the size of the host shows that *Contracaecum sp* met in four size classes, with highest number of parasites in individuals from size classes [21-31 [and [31-41 [(58.7% and 32.38% respectively).

The prevalence of *Contracaecum* sp could be explained by the strong presence of birds; final hosts of the parasite [12,28,47,31,39]. These final hosts will deposit the eggs of the parasite in the environment. These eggs hatch in 2 to 3 days with 24°C or in 5 to 7 days with 21°C [6].

The cestode *B.acheilognathi* is essentially present in winter (53 specimens collected); similar findings have been reported for *Gambusi aaffinis* in the southern United States [32]. *B. acheilognathi* is strongly present in young carps (94.6%).The presence of this cestode decreases with the increase of the size of the host. Korting [42] found 60 worms per fish in young carp from Germany. On the other hand, Bachinskii *et al*., [7], have indicated that older carp remain less prone to infestation. Kim *et al*., [40] found that for young carp (i.e. ranging in size from 9 to 16 cm) this amounted to 30 to 156 mature worms.

The use of principal component analysis shows relationship between abundance of *D. anchoratus* and *A. foliaceus* and Contracaecum sp and temperature; these parasites were more frequents in summer and autumn when water temperature and suspended material present the highest values. The statistical analysis revealed that presence of *B. acheilognathi* would be correlated by decrease of temperature and increase of water oxygenation.

Conclusion:

This study of the *C. carpio* carp captured in Lake Oubeira revealed:

- Relatively poor growth rates compared to those reported in the literature; which appears to reflect a relationship with the availability of food, and possibly other environmental factors linked to the carp's habitat
- A low diversity parasites;
- The distribution of parasites shows a relationship with the temperature and host Size : *D. anchoratus* is strongly present in the summer and in large sized carps; *Contracaecum sp* is present throughout the year, with highest infestation during summer and spring.

We wish to point out; however, that temperature is not the only element that influences the rate and the degree of infestation of the host by these parasites. As for the parasites encountered in this study; the influence of copepods on carp infestation by *B. acheilognathi, L. intestinalis,* and that of birds on infestation of these fish by *Contracaecum* sp. and *L. intestinalis* was not negligible.

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