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Structure, reproduction, and diet of *Lophogobius cyprinoides* (Gobiidae) in a lagoon of Guadeloupe (French West Indies)

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Abstract: From fish samplings (rotenone: 6 February 2002 & 13 May 2003; boxtraps: January 2008 to July 2009) in a mangrove lagoon, the demographic structure, reproductive period and diet of *Lophogobius cyprinoides* were studied. Individual fish were measured (< 1 mm), weighed (± 0.01 g), and sexed by observing the urogenital papilla, sex-ratios and total length (TL)-standard length and length-mass relationships were calculated. Five individuals per size class (2 mm) were used to study sexual maturity by macroscopic observation of gonad structure with a sexual maturity scale, and diet by qualitative and quantitative examination of digestive tract contents and calculation of the following indices: levels of fullness and vacuity; occurrence, number, and point frequencies of various food items, and quality of nutrition. Growth is isometric and sexual dimorphism in favor of males (78 vs. 64 mm), demographic structure ($18 \leq TL \leq 78$ mm) and condition evolved over time, with a distinct femininization of the population. Sexual inversion appeared from 46 mm onward, and total masculinization at 72 mm. Protogynous hermaphrodism is advantageous in a sedentary, subcryptobenthic species that is reproductively active almost throughout the year. The species has an omnivorous diet specialized in copepods and plants.

Résumé : *Structure, reproduction et régime alimentaire de* Lophogobius cyprinoides *(Gobiidae) dans une lagune de Guadeloupe (Antilles françaises).* À partir de pêches d'échantillonnage (roténone: 6/02/2002 & 13/05/2003; casier: 01/2008 à 07/2009) dans une lagune à mangrove, la structure démographique, la période de reproduction et le régime alimentaire de la population de *Lophogobius cyprinoides* ont été étudiés. Les individus ont été mesurés (mm inférieur), pesés (à 0,01 g), sexés d'après la papille urogénitale, le sex-ratio et les relations longueurs totale (TL)-standard et longueur-masse brute calculés. Cinq individus par classe de deux mm ont servi pour étudier la maturité sexuelle par observation macroscopique des gonades avec une échelle préalablement établie, et le régime alimentaire par examen qualitatif et quantitatif de leurs contenus digestifs et le calcul des indices suivants: degré de remplissage, fréquences de présence, numérique, en points des proies, et qualité de nutrition. La croissance est isométrique et le dimorphisme sexuel en faveur des mâles (78 mm contre 64 mm), la structure démographique ($18 \leq TL \leq 78$ mm) et la condition évoluent avec le temps, et la population nettement féminisée. L'inversion sexuelle apparaît à partir de 46 mm et la masculinisation totale à 72 mm. L'hermaphrodisme protogyne est suggéré chez cette espèce sédentaire subcryptobenthique dont l'activité reproductive s'effectue presque toute l'année. Son régime alimentaire omnivore est spécialisé vers les Copépodes et les plantes.

Keywords: Goby ● Mangrove ● Sex-ratio ● Protogyny ● Sedentarism

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Introduction

Lophogobius cyprinoides (Pallas, 1770) is a small teleostean fish found with a maximum standard length (SL) of 80 mm and a maximum total length (TL) of 104.5 mm that was captured for the first time by Cervigòn (1966 & 1994) south of Margarita Island in Mochima Bay (Venezuela). It belongs to the Gobiidae family, which includes more than 2000 species (Bouchereau, 2001), in the sub-order Gobiodei (2211 species according to Nelson, 2006). This goby possesses a crest on the head behind eyes, hence its vernacular name, crested goby. Its geographic distribution in the West Atlantic includes the Bermudas, Florida and the Bahamas, from North to South America (Böhlke & Chaplin, 1993). The literature on this species is scarce. Böhlke & Chaplin (1993) and Cervigòn (1966) presented elements of the species'classification while Bouchereau et al. (2010) and Bouchereau & Gros (2010) described its lateral system. Dawson (1972) compared the species to *L. cristulatus* Ginsburg, 1939 in a descriptive study. Darcy (1981) considered the crested goby in Dade County (Florida) as an opportunistic feeder because of its diverse diet including mainly algae but also amphipods, isopods, copepods, tanaïds, ostracods, insects, polychaetes, mollusks, and barnacles. Cole (1990) mentioned its possible hermaphrodism, while the common feature in gobids is gonochorism. This species lives in the brackish, shallow waters of mangrove lagoons, where it is thought to accomplish its entire life cycle in a sedentary manner. They can be seen waiting in the entrance of their den, a small hollow that they dig out of the mud themselves. The latter are more often situated around the flanks of a mangrove or directly underneath its roots than anywhere else in the lagoon bed. They may be also found under the carpet of Archaea (Gros O.: personnal communication, and personnal observation), at the edge of a talus (at higher levels than usual for the species), in the crevices of dead wood, or well hidden among the epibionts of mangrove roots. The crested gobies are difficult to capture using the classical fishing techniques of lagoon-estuary settings: bull nets, conical fishing baskets, boxtraps, beach seines, and casting nets, although the latter are very selective in the Mediterranean lagoons revealing a relative great abundance of goby species. Caberty et al. (2004) studied the trophic organization and functioning of ichthyic populations in the Manche à Eau mangrove lagoon using the trophic contribution index, but *L. cyprinoides* was rarely found in the fixed-net used.

Mangrove ecosystems are present in the paralic domains of humid, brackish, tropical and sub-tropical coastlines (Chaves et al., 1998 & 2000; Chaves & Bouchereau, 1999 & 2000). They are an important source of wealth and bio-diversity, protecting the coasts and providing food for humans. Unfortunately, deforestation has reduced these regions to the point where they are now among the most threatened ecosystems in the world (Valiela et al., 2001). A dwindling mangrove population leads directly to a reduction of biomass and diversity among typical endemic species. Indirectly, the integrity of ecosystems in adjacent continental and marine domains can also be affected by the loss of habitat. In addition, the International Union for Conservation of Nature (IUCN) is planning to evaluate risks of extinction (Red List) of a maximum of Caribean taxonomic groups, marine as continental.

In this context, the objectives of our study are first to present a general description of the biology of this not well known species, native to mangrove ecosystems: demographic structure, reproduction, and diet of the population residing in the Manche-à-Eau mangrove lagoon (French West Indies), and secondly to test a new fish sampling technique.

Material and Methods

Sampling site

Manche-à-Eau is a small lagoon located in the achipelagos of Guadeloupe (61°33'24"W-16°16'36"N) in the French Antilles (Fig. 1a). It is part of a mangrove forest bordering the Grand Cul-de-Sac Marin (Fig. 1A), a large lagoon separating the two joined islands Grande-Terre and Basse-Terre from the coral reef and the Caribbean Sea. Grand Cul-de-Sac Marin is more than 10 km long, and is surrounded by a 29 km long barrier reef. A marine channel named the Rivière Salée divides the ithsmus between Grande-Terre and Basse-Terre, opening into Grand Cul-de-Sac Marin to the north and Petit Cul-de-Sac Marin to the south (Fig. 1A). The Manche-à-Eau lagoon adjoins this channel, thereby communicating with the west side of the muddy, protected, and inundated mangrove lagoon known as Grand Cul-de-Sac Marin.

The sediment of the Manche-à-Eau lagoon is poorly oxygenated and consists of very fine silt. The trees are mainly red mangroves, *Rhizophora mangle* Linné, 1753. The site is permanently flooded with warm, brackish water, and the shape of the lagoon bed is unsettled. The lagoon measures 970 m by 620 m, its circumference is 4661 m, and its surface area is 281.7×10^3 m^2. Its average depth is 1.5 m, and its maximum depth is 3.0 m in the west depression (Mantran et al., 2009a). Each tide renews 14.8% of the water volume. This fact, combined to the active and varied hydrodynamism of the site, tends to vivify the ecosystem. Most of the lagoon's area is classified as zone III (Fig. 1B), relatively unconfined (Bouchereau et al., 2008) according to the biological zonation based on the confinement

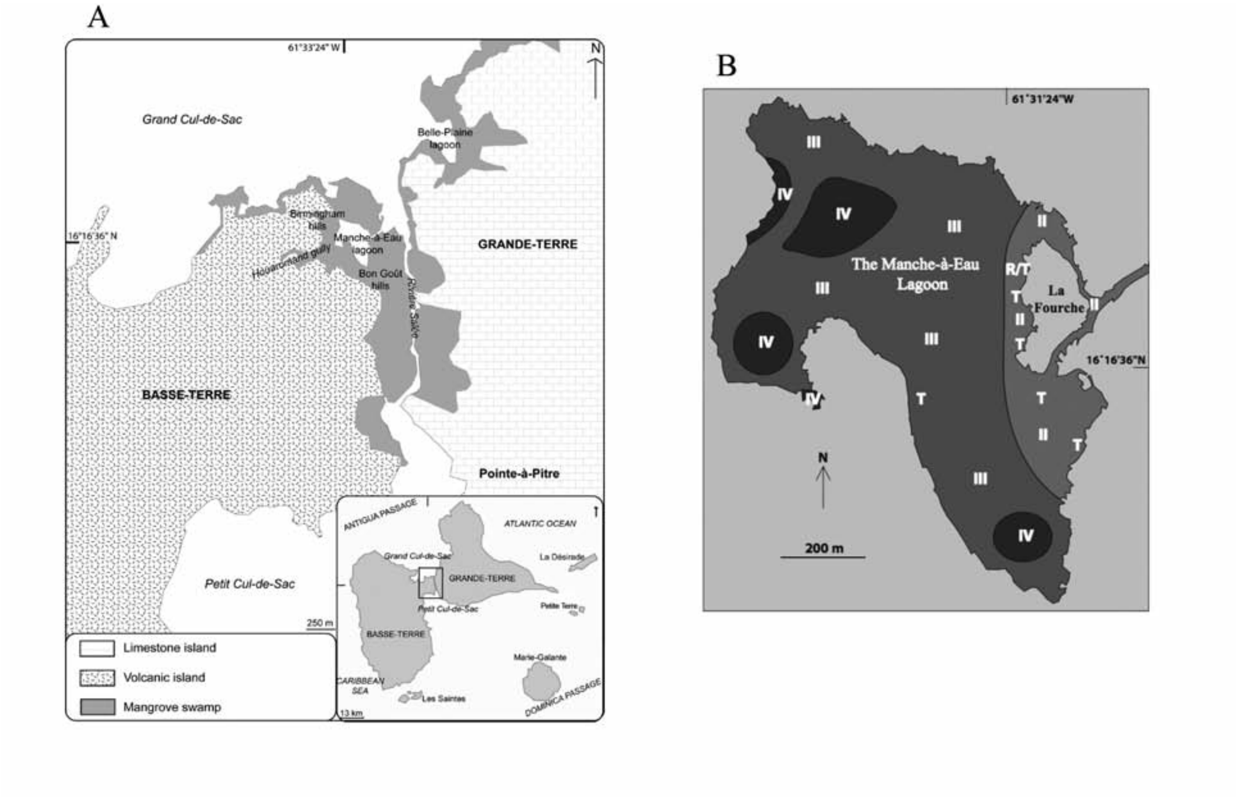

Figure 1. *Lophogobius cyprinoides.* **A**. Location of the Manche-à-Eau lagoon in Guadeloupe and Basse-Terre. **B**. The Manche-à-Eau lagoon and its biological zones (following Mantran et al., 2009b). The annotations in panel (b) are II: beginning of the paralic domain, limited by the complete disapearence of Echinoderm species, III: dominated by composite species of bentic macrofauna (marine or paralic origin), IV: presence of exact paralic species; fish sampling places with R: rotenone, T: boxtraps.

Figure 1. *Lophogobius cyprinoides.* **A.** Localisation de la lagune de la Manche-à-Eau en Guadeloupe et sur Basse-Terre. **B.** La lagune de la Manche-à-Eau et sa zonation biologique (d'après Mantran et al., 2009b). Légendes de (a) de haut en bas : calcaire d'origine récifale de l'île de la Grande-Terre ; sols volcaniques de l'île de la Basse-Terre ; mangrove littorale ; (b): II : début du domaine paralique, limitée par la disparition totale des Échinodermes, III : dominée par les espèces mixtes (marines et paraliques) de la macrofaune benthique, IV : présence d'espèces strictement paraliques; pêches d'échantillonnage avec R : la roténone, T : les casiers.

concept of Guélorget & Perthuisot (1983). In Guadeloupe there are two principal seasons: the dry season, centered on February and March, and the humid season centered on the period extrending from July to October, the latter corresponding to the cyclonic season. There are two transition seasons characterized by less rain than during the cyclonic season.

The ichthyic community is dominated by six species (94.4% in number; 66.6% in biomass) belonging to four families (Bouchereau & Chantrel, 2009): the clupeid *Harengula clupeola* (Cuvier, 1829), 44.4% in number, the gerreids *Diapterus rhombeus* (Cuvier, 1829), 26.2%, *Eucinostomus argenteus* Baird & Girard, 1855, 2.2%, and *Eucinostomus gula* (Quoy & Gaimard, 1824), 14.7%, the engraulid *Anchoa lyolepis* (Evermann & Marsh, 1900), 4.1%, and the sciaenid *Bairdiella ronchus* (Cuvier, 1830), 2.8%.

Field sampling

With regard to the ecology of the crested goby and the different unsuccessfull fishing methods used by the laboratory before (beach seine, fixed net like « *capéchade* »), we decided to experiment another method known as more effective (Bouchereau & Lam Hoaï, 1997), using rotenone for capturing cryptic fishes like *L. cyprinoides*. This product prevents the creation of ATP in cells by interferring with the mitochondria. It is easily absorbed by animals with branchial respiration. It can be bought as a powder, and once mixed with wet sand (at a concentration of 7 $g.L^{-1}$, just targetting fish without effect on other organisms), the poison acts on an entire column of water. The area sampled (337 m^2) is delimited by the bank of the lagoon and a very fine gillnet (stretched out, the links are only 1 cm wide). Thirty minutes after dropping the rotenone, all the fish in the column could be collected with small dipping nets. This method enables us to catch small individuals, as well as fish with sedentary and territorial habits that would be difficult to capture by other, more common means (e.g., bull nets, conical fishing baskets, casting nets, boxtraps, and beach seines). A sampling bias might exist, because there is no guarantee that 100% of the bottom-dwelling fish have been caught since some fish may escape by swimming over the net or stand in a cave.

As an alternative to rotenone, between January 2008 and June 2009 we tried out an experimental fishing method, placing three boxtraps (dimensions 44×35×31 cm) baited with vegetables (ecological traps). The traps were dropped near mangrove roots at various points along the banks of the lagoon (Fig. 1b) and regularly (every other week) hauled in to extract the trapped fish. They were then replaced with the same volume of vegetable debris. The goals of this experiment were (i) to design a new and ecological fishing method targeting cryptic fish species mainly *L. cyprinoides*, (ii) to obtain more information on the duration of the crested goby reproduction period, by means of regular easy visits of box traps.

Some of the individuals (Table 1) caught in 2002 and 2003 were refrigerated (alive), while others (dead) were fixed on site with formol (5% formaldehyde in seawater). The specimens collected in 2008 and 2009 were all first refrigerated and then fixed with formol. The first sample was collected on 6 February, 2002, between 10 and 11 a.m. The second was collected on 13 May, 2003, between 9 and 11 a.m. in shallow waters on the West side of La Fourche Island (Mantran et al., 2009a), situated at the entrance of Manche-à-Eau lagoon (Fig.1b). A portion of the first sample (50 individuals) was referenced by the National Museum of Natural History under number 20023386.

Laboratory measurements

Ichthyofauna. The fish assembled were sorted, identified using specialized guides (FAO, 1978; Robins & Ray, 1986), then enumerated and weighed to the gram.

Demographic structure. *L. cyprinoides* individuals were sexed by observing the shape of the urogenital papilla, which is conic in males and rectangular in females (Bouchereau et al., 2010; Bouchereau & Gros, 2010). Individuals not showing sufficient dimorphism were either sexed by observing the gonads after evisceration, or classified as immature.

The total (TL) and standard (SL) lengths of the *L. cyprinoides* specimens were measured to the inferior millimeter with an ichthyometer. The total mass (TM) and eviscerated mass (VM) of each individual were then measured to the nearest hundredth of a gram. Finally, the sexual maturity of each individual was evaluated by observing its gonads with a stereo microscope. The scale of maturity used (Table 2) was based on our own observations in the present study as well as others on Gobiidae (Bouchereau, 1994). The ovary mass GM was weighted (to the mg) on females from the 2009 sample.

Diet. To study the diet of this species, regardless of sex, five individuals from each size class (defined as a 2 mm interval in TL) were selected. After measuring TL, TM and VM, the entire digestive tube (from esophagus to anus) was extracted and placed in a pillbox for subsequent analysis. Each digestive tract was examined under a stereo microscope, and its fullness evaluated on the following scale: 0) empty, 1) one-quarter full, 2) half full, 3) three-quarters full, and 4) full. Preys were identified to the lowest taxa when possible and grouped in several items. When preys were damaged, the number of preys was deduced by counting appendages and other identifiable fragments. Fish scales found were considered as artifacts of evisceration, and not taken into account.

Data analysis

Relationship between sizes, and between size and mass. The average total lengths were calculated for the February 2002 and May 2003 samples. For the latter case, we also

Table 1. *Lophogobius cyprinoides.* Samples realised between February 2002 and June 2009 by two experimental fishing techniques: rotenone (R) and boxtrap (T). N_t: number of area treated with rotenone, or boxtraps visited; N_i: number of individuals captured; cpue: catch per unit effort in number of individuals captured in the same area (337 m^2) with rotenone, or per boxtrap fishing two weeks long.

Tableau 1. *Lophogobius cyprinoides.* Échantillonnages par pêches expérimentales à la roténone (R) et au casier (T) entre février 2002 et juin 2009; N_t : nombre de surfaces traitées à la roténone, ou de casiers visités; N_i: nombre d'individus capturés, cpue: capture par unité d'effort en nombre d'individus capturés à la roténone dans la même surface traitée (337 m^2), ou par casier pêchant deux semaines durant.

Year	**2002**	**2003**	**2008**						**2009**				
Month	Feb.	May	Jan	Mar	Apr	May	Jul	Nov	Jan	Mar	Apr	May	Jun
R or **T**	R	R	T	T	T	T	T	T	T	T	T	T	T
$\mathbf{N_t}$	1	1	3	3	6	3	3	3	18	12	6	30	12
$\mathbf{N_i}$	133	533	8	12	6	8	26	5	14	12	5	31	16
cpue	0.4	1.6	2.7	4.0	1.0	2.7	8.7	1.7	0.8	1.0	0.8	1.0	1.3

Table 2. *Lophogobius cyprinoides*. Sexual maturity scale of gonads, after their structure observation (present work).
Tableau 2. *Lophogobius cyprinoides*. Échelle de maturité sexuelle des gonades, d'après l'observation de leur structure (présente étude).

Stage	Level of maturity of the ovaries	Level of maturity of the testicles
I Immature	The ovaries are separated, flattened, and have lengths about 40% of the abdominal cavity.	The testicles are flattened cones, and their length is 20% of the abdominal cavity. Their appearance is milky white, slightly translucent, and very homogenous.
II First maturation or sexually inactive	The separated ovaries have become cylindrical and translucent, and their length is now 60% of the abdominal cavity. Melanophores are scattered over the ovary surface, the developing ovocytes are barely perceptible, and the color varies from white to beige.	The testicles are shaped like rounded ribbons, and their length is 40% of the abdominal cavity. Their color is similar to stage I, but lobules appear and the surface is covered with a more or less homogenous distribution of melanocytes.
III Maturation	The ovaries are moderately rounded, firmer, closer together or even in contact on the posterior end. The surface has become grainy, its color from beige to pale yellow tinted gold. The color of the ovocytes is similar to that of the ovary. The length of the ovaries can increase up to 70% of the abdominal cavity.	The testicles resemble stage II, but are more rounded and cover 70% of the abdominal cavity.
IV Pre-laying	The ovaries are rounded cylinders yellow to orange in color, occupying 90% to 100% of the abdominal cavity. The ovarian membrane is very fine. The ovocytes are mature, perfectly visible, transparent with a large yellow-orange spot in the center.	The testicles are large, rounded, and blade-shaped, measuring nearly 100% of the abdominal cavity in length. The accessory glands are large (70% of the abdominal cavity) with easily visible lobules. A pale yellow or pink band appears along the center of the testicle.
V Post-laying	The ovaries are weakly attached to the abdominal cavity, cover 40% of its length, and have become cylindrical and flaccid. Their color is beige to pale yellow, with orange pigment scattered over the surface. The ovocytes are on their way to atresia, with residual transparent ovules. There are numerous ovocytes characteristic of stage III throughout the distended ovarian membrane.	Similar to stage IV, but the testicles are no longer rounded and present orange spots on the surface.

analysed the relationship between length and sex. Among most of fishes and particularly Gobiids (Bouchereau, 1994), the relationship between total length (TL) and standard length (SL) has the form TL = a × SL + b, and the one between total mass and total length has the form TM = c × TL^d, or equivalently ln(TM) = d × Ln(TL) + Ln(c) where a, b, c, d are constants. Both relationships were fit to the data using the method of least squares.

Size distribution, sex ratio, and condition. The TL data were classified in size classes of 2 mm to obtain the size classes frequencies per sample and per sex. In addition to the whole population, the population was divided by sample and sex, and the sex ratio (male to female) was also calculated. Finally, the average condition coefficient (K_c) was computed for each size class, sample date, and sex:

$$K_c = 100 \times (TM/c \times TL^d) \quad (1)$$

Reproduction. The reproductive period was estimated by the observation of sexual maturity stages from January 2008 to June 2009. The size at first sexual maturity, defined as the size class for which 50% of individuals in the *cumulative* distribution is sexually mature (stages II through V), was retained as the smallest specimen observed with ripening gonad (male and female). The Gonadosomatic Index:

$$(GSI = 100 \times GM/VM) \quad (2)$$

was calculated using the 2009 sample.

Diet. To describe diet content, we used the following feeding indexes:

- Degree of fullness of digestive tract (DF) (Rosecchi & Nouazé, 1987) being the percentage of the number Nf of digestive tracts presenting a given fullness (0, 1, 2, 3, 4) to the total number TN of digestive tracts extracted:

$$DF_{0,1,2,3,4} = 100 \times (Nf_{0,1,2,3,4}/TN) \quad (3)$$

- Occurrence frequency (OP) (Rosecchi, 1987) being the percentage of number of digestive tracts including food

Table 3. *Lophogobius cyprinoides.* Points attributed to preys according to digestibility and size, adapted from Bouchereau & Guélorget (1999).

Tableau 3. *Lophogobius cyprinoides.* Points attribués aux proies d'après leur digestibilité et leur taille ; adapté de Bouchereau & Guélorget (1999).

Prey	Points	Prey	Points
Polychaetes	40.0	Nematods	5.0
Achaetes	40.0	Insects	5.0
Peneidae	30.0	Marginellidae	5.0
Euphausiacae	20.0	Animal/vegetable Débris	5.0
Peneidae	30.0	Bivalves	1.0
Flabelliferae	20.0	Cocculinidae	1.0
Cumaceans	15.0	Caecidae	1.0
Isopods	10.0	Gastropods	1.0
Anthuridae	10.0	Copepods	1.0
Amphipods	10.0	Ostracods	1.0
Mysidacae	10.0	Acarians	1.0
Crustaceans	10.0	Foraminifera	1.0
Decapods	10.0	Eggs	0.5
Larvae	5.0	Other Foods	0.5

item i (Di) to the total number of examined tracts with food (Dt) (empty tracts excluded):

$$OP = 100 \times (Di/Df) \quad (4)$$

• Numeric frequency (NP) (Joyeux et al., 1991) being the percentage of the total number of each food item i (Ni) to the total number of identified food items (Nt):

$$NP = 100 \times (Ni/Nt) \quad (5)$$

• Points frequency (PP) (Bouchereau & Guélorget, 1999) being the percentage of points corresponding to each food item i (Pi) to the total number of points of identified food items (Pt):

$$PP = 100 \times (Pi/Pt) \quad (6)$$

To calculate PP, the method (Bouchereau & Guélorget, 1999) assigns an arbitrary number of points (Table 3) as a function of the state of satiety of the predator's digestive tract and of the mass of prey observed during digestion. Points were given to each zoological group in proportion to the average size (wet mass) of these animals (undigested). This method enables a better evaluation of the original food intake based on digested remains. Thus, the number of points assigned in this case reflects the level of satiety at the moment when preys were swallowed

• Index of relative importance (IRI) (Pinkas et al., 1971) was calculated using these three last indices for each food item *i*:

$$IRIi = (NPi + PPi) \times Opi \quad (7)$$

It is represented by a rectangular area, resolved by plotting the three values on a 3-way graph.

Nutrition quality (NQ) (Joyeux et al., 1991) being the percentage of the total number of points (Pt) in all food items to the product of the total number (Dt) of digestive tubes examined with the mean eviscerated individual mass mVM:

$$NQ = (100 \times Pt)/(Dt \times mVM) \quad (8)$$

It expresses the relationship between the resource ingested and the mean eviscerated mass (mVM), avoiding the effects induced by intersexual differences and seasonal changes of gonad mass and those caused by the variation of repletion state.

Statistical tests of Chi-squarred (χ^2) and Student's t-test for mean comparison were used in order to detect significant or unsignificant differences between series of values.

Results

Fishing efficiency

The number of fish caught (Table 1) at a time with the rotenone was 133 in February 2002 and 533 in May 2003 whereas from 5 individuals (November 2008) up to 31 individuals (May 2009) per month were caught with the boxtraps (3 to 30 respectively). The catch per unit effort (cpue) varied (Table 1) from 0.4 to 1.6 individuals per m^2 with the rotenone for one attempt and from 0.8 to 8.7 individuals per boxtrap fishing for two weeks, i.e. from 0.06 to 0.6 individuals per boxtrap and per day.

Demographic structure

Length-length and mass-length relationship. The parameters of functions relating total length (TL) to both standard length (SL) and total mass (TM) are presented in Table 4 for the two sampling periods and sexes. There was not significant difference between sexes in the relation $TL = a \times SL + b$. The exponent of the power law $TM = c \times TL^d$ was very close to 3 in both sampling periods. Within any given size class, the total mass was always higher in May 2003 than in February 2002, but no significant difference appears.

Size distributions. The average total length (Table 5) of the February 2002 population was 40.4 mm, while that of the May 2003 population was 36.5 mm. The maximum length was always larger in males (TL = 78 mm) comparatively to females (TL = 64 mm). The size (TL) distributions of the 2002 and 2003 populations, all sexes taken into account ranged from 24 to 70 mm and from 18 to 78 mm, respectively (Fig. 2) for the February 2002 and May 2003 samples. Small size classes (TL < 40 mm) appeared and were more abundant in May 2003 than in February 2002, in opposition to the larger size classes (TL $\geq$ 40mm). Regarding each sex (Fig. 3A & B), the cohorts were also

Table 4. *Lophogobius cyprinoides*. Parameters a and b of total length (TL)-standard length (SL) and mass (TM)-length (TL) relations; r: correlation coefficient, n: number of specimens; - : no data.

Tableau 4. *Lophogobius cyprinoides*. Paramètres a et b des relations longueurs (en mm) totale (TL)-standard (SL) et masse (TM)-longueur totale (TL) ; r : coefficient de corrélation ; n : effectif ; - : pas de données.

Y = f(x)	date	a	b	r²	n	TL range	SL range	TM range
TL = aSL + b	total 2003	1.235	-0.593	0.984	533	18-78	15-62	-
	males	1.248	-0.902	0.986	124	18-78	15-62	-
	females	1.213	-0.021	0.979	409	19-54	16-45	-
TM = aTL^b	total	$1.412*10^{-5}$	2.994	0.987	205	18-78	-	0.08-6.18
	02/2002	$1.154*10^{-5}$	3.036	0.908	97	24-70	-	0.21-4.59
	05/2003	$1.525*10^{-5}$	2.983	0.993	108	18-78	-	0.08-6.18

Table 5. *Lophogobius cyprinoides*. Average total lengths (TL) and mass (TM) by sampling date and by sex; n: number of specimens; sd = standard deviation.

Tableau 5. *Lophogobius cyprinoides*. Longueurs (TL) et masses totales (TM) moyennes selon la date d'échantillonnage et le sexe ; n : effectif ; sd : écart-type.

Date	Sample	n	TL (mm)	sd	Length range	n	TM (g)	sd	Mass range
February 2002	Both sexes	136	40.382	9.348	24-70	97	1.125	0.929	0.18-4.59
	Males	12	46.833	13.253	26-70	-	-	-	-
	Females	124	39.950	8.639	24-64	-	-	-	-
May 2003	Both sexes	533	36.531	8.975	18-78	205	1.234	1.126	0.08-6.18
	Males	124	41.315	13.336	18-78	-	-	-	-
	Females	409	35.081	6.508	19-54	-	-	-	-

positioned differently in the two distributions. For example, the first female cohort appeared between 26 and 32 mm in 2002, and 20 and 28 mm in 2003; in the large size classes (TL ≥ 46 mm), females became from February 2002 to May 2003 less numerous, inversely to males. Each cohort, regardless to sex, experienced a similar displacement. These differences could be attributed to growth of individuals between February and May in a supposed year, when considering chronology and cinetic of size populations. Males were significantly longer (Table 5) than females in 2002 ($p < 0.05$) and 2003 ($p < 0.01$). The February 2002 population (Fig. 3a) presented four female cohorts: 24-30 mm, 32-36 mm, 38-48 mm, and those longer than 48 mm. Among males, there were too few specimens to distinguish particular modes. The May 2003 population (Fig. 3B) revealed four cohorts in both sexes. Females fell into the range 18-26 mm, 28-34 mm, 36-44 mm, 46-56 mm and males into the range 20-32 mm, 34-40 mm, 42-56 mm and 58-78 mm.

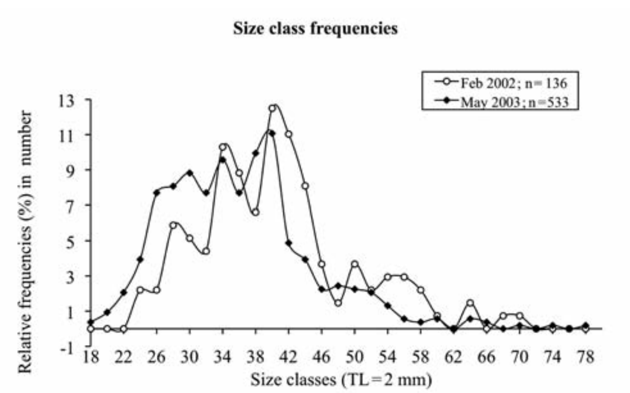

Figure 2. *Lophogobius cyprinoides*. Distribution of relative frequencies (%) in number by size class of 2 mm (TL) in February 2002 and May 2003.

Figure 2. *Lophogobius cyprinoides*. Distribution des fréquences relatives (%) en nombre des classes de tailles de 2 mm (TL) en février 2002 et mai 2003.

<u>Sex ratios</u>. The sex ratio (males/females) of *L. cyprinoides* was 0.072 (8/124) in February 2002 and 0.306 (125/408) in May 2003. Females were therefore predominant in both samples (Fig. 3A & B). Due to the small number of males in February, the sex ratio was not calculated as a function of size class (TL). In May, the proportion of males (Fig. 4) increased with size after 34 mm. For specimens of 58 mm

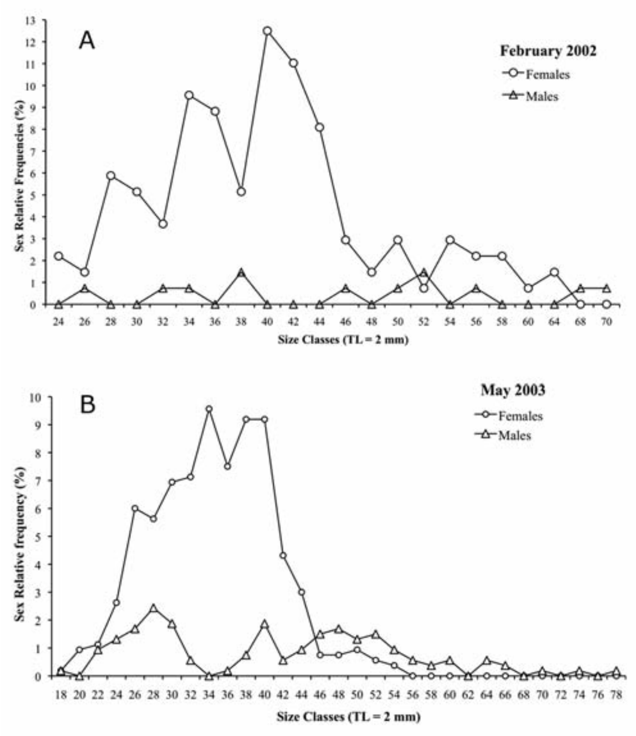

Figure 3. *Lophogobius cyprinoides.* Distribution of sex relative frequencies (%) by size class of 2 mm (TL) in A: February 2002; B: May 2003.

Figure 3. *Lophogobius cyprinoides.* Distribution des fréquences relatives (%) des mâles et femelles selon la classe de taille de 2 mm (TL) en A : février 2002; B : mai 2003.

Table 6. *Lophogobius cyprinoides.* Proportion (%) each stage of sexual maturity by sampling date, determined by observing the gonads.

Tableau 6. *Lophogobius cyprinoides*. Proportions (%) des stades de maturité sexuelle observés sur les gonades selon la période d'échantillonnage.

Stages	February 2002		May 2003	
	Males (n)	Females (n)	Males (n)	Females (n)
I	22.22 (2)	43.18 (38)	14.03 (8)	7.84 (4)
II	22.22 (2)	25.00 (22)	19.30 (11)	13.73 (7)
III	33.33 (3)	28.41 (25)	19.30 (11)	43.14 (22)
IV	22.22 (2)	2.27 (2)	3.51 (3)	0.00 (0)
V	0.00 (0)	1.14 (1)	43.86 (25)	35.29 (18)
Total n	9	88	57	51

or more, the proportion of males was 100%. Male/female parity occurred at 44 mm; between 44 and 58 mm, the proportion of males rose steadily.

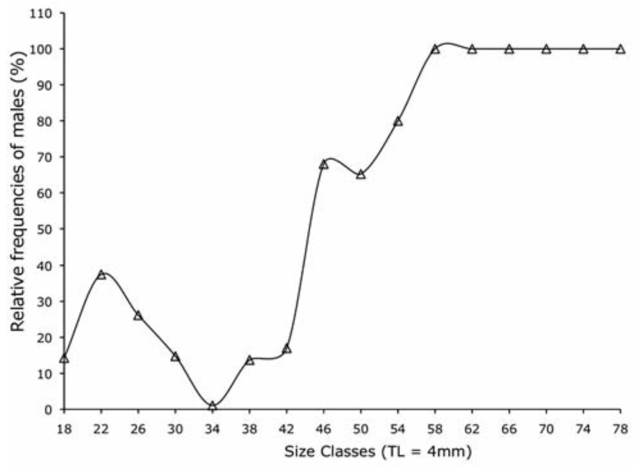

Figure 4. *Lophogobius cyprinoides.* Percentage of males by size (TL) class (4 mm) in the May 2003 sample.

Figure 4. *Lophogobius cyprinoides.* Pourcentage de mâles par classes de tailles de 4 mm (TL) dans l'échantillon de mai 2003.

Gonad maturity. The macroscopic observation of gonads was done on 97 individuals from the samples collected in February and 108 in May (Table 6), covering all size classes. Once stage III was observed in gonads, it was known (Fontana, 1969; Fontana & Le Guen, 1969) that spawning will happen. Thus, 55% of males and 31% of females were involved in the reproductive activity in February 2002, and more in May 2003 (66% of males and 78% of females). Sexually mature gonads were observed in April, May, July and November 2008, and in January and from March to June 2009 (Table 7). Stage III was always represented, and stage IV was the most common in June and July. In 2009, the mean GSI (Table 8) varied between 2.6% in January and 1.7% in June. From 72 specimens observed, 46 were ripening. The percentage of ripening females decreased with size, and sizes at first maturity were 35 mm for females and 40 mm for males (Table 8).

Condition. The mean condition factors K_c observed in the *L. cyprinoides* population were 1.33 x10^{-3} (n = 97, standard deviation sd = 0.14 x10^{-3}) and 1.44x10^{-3} (n = 108, sd = 0.17 x10^{-3}) for the months of February and May respectively. There was a significant difference (K_c2002 - K_c2003 = |11.48 x10^{-4}|, $p < 0.01$) between the two means in favor of the May 2003 sample. The mean K_c value per size class increased little with size (Fig. 5), remaining close to the overall means calculated for the two periods. The regression curve position of mean Kc against size classes TL (2 mm) of May 2003 was above that of February 2002. Because of the weakness in number of males in each size class in the February 2002 sample, only the May 2003 sample was taken into consideration to compare mean Kc

Table 7. *Lophogobius cyprinoides.* Stages of sexual maturity observed in the gonads (according to the sexual maturity scale in Table 2) collected by boxtrap in 2008 and 2009; stages in bold are the more observed; M: males; F: females; **I**: immature; - : no data.

Tableau 7. *Lophogobius cyprinoides.* Stades de maturité sexuelle observés sur les gonades (d'après l'échelle de maturité sexuelle du Tableau 2) échantillonnées au casier en 2008 et 2009 ; les stades en gras sont les plus observés ; M : mâle ; F : femelle ; I : immature ; - : pas de données.

Year/Month	Jan	Mar	Apr	May	Jun	Jul	Nov
2008	-	-	I,**II**,**III**	I,II,**III**	-	I,II,**III**,IV	II-**III**
Number M/F/**I**	-	-	5/1	7/9	-	5/20/**1**	2/3
2009	**I**,**II**,III	I,II,**III**	**III**	II,**III**,IV	I,II,**III**,IV	-	-
Number M/F/**I**	2/1	4/6	1/4	9/16/**3**	6/10	-	-

Table 8. *Lophogobius cyprinoides.* Mean Gonadosomatic index (GSI) of females sampled from January to June 2009 and number n per size classes (TL in mm) and sex of 46 ripening specimen caught in the boxtraps from January to June 2009 and extreme values of length and weight (TM in g); N: number of females sampled; min: minimum; max: maximum; sd: standard deviation.

Tableau 8. *Lophogobius cyprinoides.* Variations de l'indice gonadosomatique (GSI) moyen des femelles échantillonnées de janvier à juin 2009 et effectif n par classe de taille (TL en mm) et selon le sexe des 46 individus en maturation capturés dans les casiers entre janvier et juin 2009 et valeurs extrêmes de longueur et de masse (TM en g) ; N : nombre de femelles échantillonnées ; min : minimum ; max : maximum ; sd : écart-type.

Month	N	TL min	TL max	mean GSI (min – max)	sd	stages
January	3	36	45	2.59 (1.68 – 3.61)	0.792	II, III
March	7	37	48	1.74 (0.82 – 2.47)	0.640	I, II, III
April	3	40	46	3.98 (1.21 – 6.93)	2.340	II, III
May	1	49	49	1.81 (–)	–	III
June	10	36	66	1.72 (0.08 – 9.75)	2.947	I, II, III, IV

TL (5 mm)	35	40	45	50	55	60	65	70	n	min TL – TM (date)	max TL–TM (date)
n Females F	6	5	11	3	0	0	1	0	26	35 – 0.57 (18/05)	66 – 3.69 (02/06)
n Males M	0	4	2	3	1	5	2	3	20	40 – 1.00 (16/01)	72 – 5.22 (13/01)
TL (10 mm)	30	40	50	60	70						
100xF/(F+M)	100	72.7	42.9	12.5	0						

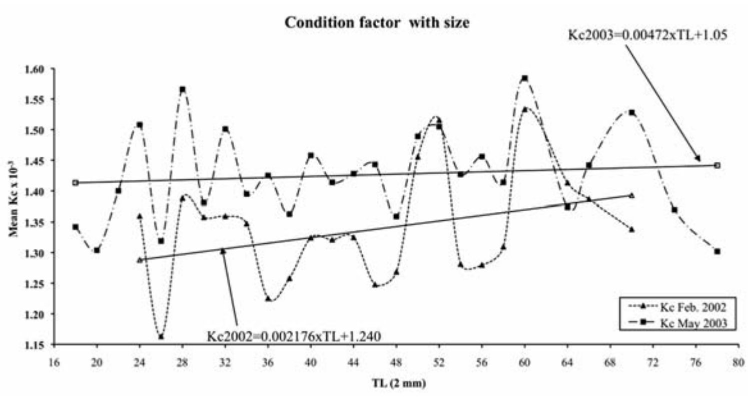

Figure 5. *Lophogobius cyprinoides.* Mean K_c in each size class of 2 mm (TL) for the February 2002 and May 2003 samples.

Figure 5. *Lophogobius cyprinoides.* Distribution des K_c moyens par classe de taille de 2 mm (TL) selon la date d'échantillonnage.

to size according to the sex (Fig. 6). Both data series (in May) and regression curves decreased with size with an advantage for males showing a slightly higher mean K_c value (1.49 x10-3) than for females (1.41 x10-3).

Diet

Ninety seven individuals from the February 2002 sample and 108 individuals from the May 2003 sample were eviscerated to study their digestive tracts content.

Digestive tract fullness. In the February 2002 sample, 37.1% of individuals had digestive tracts three-quarter full (DF3), 25.8% were half full (DF2), 19.6% were completely full (DF4), and 16.5% were one-quarter full (DF1). The

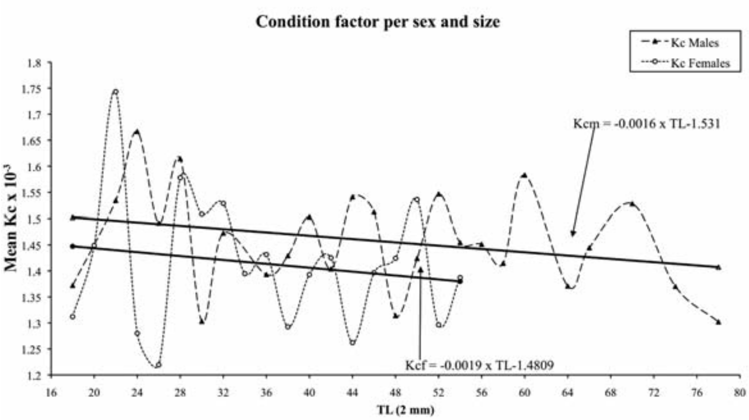

Figure 6. *Lophogobius cyprinoides.* Distribution of mean condition factors K_c by size class of 2 mm (TL) and sex in May 2003.

Figure 6. *Lophogobius cyprinoides.* Distribution des facteurs de condition moyens K_c par classe de taille de 2 mm (TL) selon le sexe en mai 2003.

vacuity coefficient (i.e., the fraction of empty digestive tracts) was therefore only 1.0%. In May 2003, the distribution was 39.8% for DF3, 24.1% for DF4, 19.4% for DF2, and 12.0% for DF1. In this sample, only 5 of the 108 individuals (4.6%) had empty tracts.

Diet composition and preferences. The diet spectrum of *L. cyprinoides* was composed of a total of 17 items, 15 in February 2002 and 16 in May 2003, consisting mainly in vegetable debris, copepods, amphipods, eggs, ostracods and deacapods (Table 9).

With regard to both sampling periods (Fig. 7A & B), and considering all three frequencies (occurrence, numeric, and points) with the index of relative importance (IRI), the dietary spectrum of *L. cyprinoides* was essentially founded on copepods and vegetable debris or inversely. The other common main items, such as eggs, amphipods, ostracods, decapods, nematods and larvae were less important and with a lower IRI. Compared to February 2002, animal debris disapeared and foraminifera and isopods appeared in the tract contents observed in May 2003. In the minor items (Table 9), crustaceans were not observed in the contents of May 2002 sampling period when polychaets and Cumaceans were present. Some of the extreme size classes in both samples of 2002 and 2003 (Tables 10 & 11) were not fully represented. Five specimens per size class were requested in the method. New size classes, except for size classes filled by one or two specimens, juveniles ($18 \leq TL \leq 22$) and large adults ($74 \leq TL \leq 78$) appeared in the May sample: between 9 and 12 items were found in February 2002 sample with $24 \leq TL \leq 56$, and between 8 and 13 in May 2003 with $20 \leq TL \leq 64$. Among the major preys (Tables 10 & 11) the index of relative importance IRI represented in Log_{10} (IRI), increased with size for the item

Table 9. *Lophogobius cyprinoides.* Nutrition indices: occurrence frequencies OP, numeric frequencies NP, point frequencies PP and index of relative importance IRI of various prey categories ingested in February 2002 and May 2003; LogIRI: Log_{10} (IRI).

Tableau 9. *Lophogobius cyprinoides.* Indices alimentaires: fréquences d'occurence OP, numérique NP, en points PP et index d'importance relative IRI des différentes catégories de proies ingérées en février 2002 et mai 2003 ; LogIRI : Log_{10} (IRI).

	February 2002						May 2003					
Food item	**OP**	**NP**	**PP**	**IRI**	**%IRI**	**LogIRI**	**OP**	**NP**	**PP**	**IRI**	**%IRI**	**LogIRI**
Vegetable Debris	89.69	22.01	45.70	6073	35.8	3.78	88.99	61.07	82.94	12815	76.4	4.11
Copepods	98.97	54.14	22.49	7584	44.7	3.88	92.66	25.82	7.01	3042	18.1	3.48
Eggs	52.58	10.26	2.13	651	3.8	2.81	51.38	5.37	0.73	313	1.9	2.50
Amphipods	79.38	3.18	13.22	1302	7.7	3.11	45.87	1.07	2.91	182	1.1	2.26
Ostracods	76.29	4.95	2.06	535	3.2	2.73	44.95	2.33	0.63	133	0.8	2.12
Decapods	54.64	0.94	3.90	264	1.6	2.42	38.53	0.58	1.59	83	0.5	1.92
Foraminifera	3.09	0.04	0.01	0	0.0	0.00	48.62	1.17	0.32	72	0.4	1.86
Nematods	50.51	1.64	3.40	255	1.5	2.41	28.44	0.82	1.11	55	0.3	1.74
Larvae	24.74	0.45	0.94	34	0.2	1.53	25.69	0.55	0.75	33	0.2	1.52
Bivalves	5.15	0.06	0.03	0	0.0	0.00	36.7	0.65	0.18	30	0.2	1.48
Isopods	30.93	0.68	2.81	108	0.6	2.03	20.18	0.24	0.66	18	0.1	1.26
Polychaetes	-	-	-	-	-	-	5.5	0.06	0.69	4	0.0	0.60
Cumaceans	-	-	-	-	-	-	5.5	0.07	0.30	2	0.0	0.30
Animal Debris	37.11	1.51	3.13	172	1.0	2.24	5.5	0.09	0.13	1	0.0	0.00
Non identified	8.25	0.10	0.04	1	0.0	0.00	5.5	0.06	0.01	0	0.0	0.00
Insects	2.06	0.02	0.05	0	0.0	0.00	1.83	0.02	0.03	0	0.0	0.00
Crustaceans	2.06	0.02	0.10	0	0.0	0.00	-	-	-	-	-	-

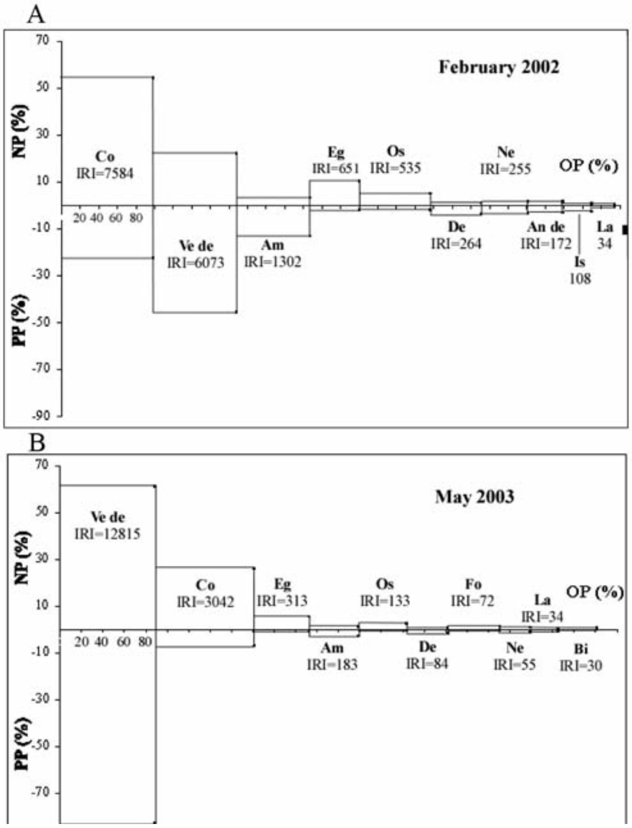

Figure 7. *Lophogobius cyprinoides.* Percent composition of ten major prey items collected in February 2002 (A) and May 2003 (B), by number (NP), mass in points (PP) and occurrence (OP) in total number of digestive tracts. The Index of relative importance (IRI) is represented by size of respective rectangles. Co: copepods; Ve de: vegetal debris; Am: amphipods; Eg: eggs; Os: ostracods; De: decapods; Ne: nematods; An de: animal debris; Is: isopods; La: larvae; Fo: foraminiferae; Bi: bivalves.

Figure 7. *Lophogobius cyprinoides.* Composition en pourcentage des dix principales catégories de proies observées dans les contenus digestifs en février 2002 (A) et mai 2003 (B), selon le nombre (NP), la masse en points (PP) et la présence (OP). L'indice d'importance relative (IRI) de chaque catégorie de proies est représenté par les surfaces correspondantes. Co : Copépodes ; Ve de : débris végétaux ; Am : Amphipodes ; Eg : œufs ; Os : Ostracodes ; De : Décapodes ; Ne : Nématodes ; An de : débris animaux ; Is : isopodes ; La : larves ; Fo : Foraminifères ; Bi : Bivalves.

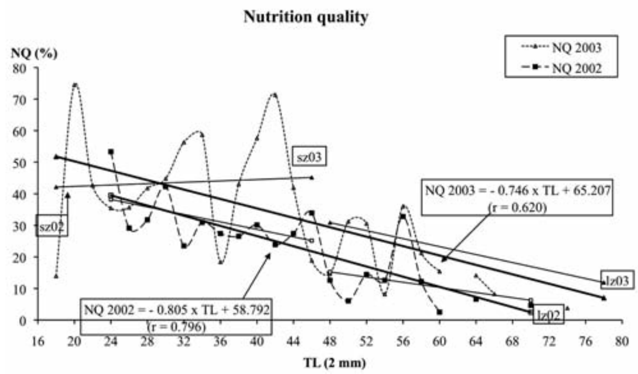

Figure 8. *Lophogobius cyprinoides.* The nutrition quality index NQ (in %) per length classes (TL 2 mm) in February 2002 and May 2003 samples and the corresponding linear regression curves. r: correlation coefficient; regression curves in 2002 and 2003 respectively for small sz02, sz03 (TL ≤ 46 mm) and large size classes lz02, lz03 (TL > 46 mm).

Figure 8. *Lophogobius cyprinoides.* L'indice de qualité de nutrition NQ (en %) suivant les classes de tailles (TL 2 mm) dans les échantillons de février 2002 et mai 2003. n: coefficient de corrélation; droites de régression en 2002 et 3003 respectivement pour les petites sz02, sz03 (TL ≤ 46 mm) et les grandes lz02, lz03 (TL > 46 mm) classes de tailles.

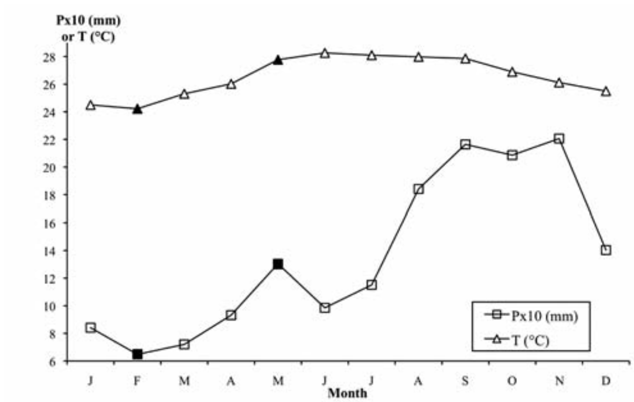

Figure 9. *Lophogobius cyprinoides.* Mean pluviometry P (in mm) and temperature T (in °C) of the studied area over a "standard" year, based on 30 years of Méteo France data, from 1971 to 2000. The values were measured at Raizet, closest weather station to Manche-à-Eau lagoon. The solid points represent the months during which specimens were collected using rotenone.

Figure 9. *Lophogobius cyprinoides.* Année référence de l'évolution de la pluviométrie P (en mm) et de la température T (en °C) moyennes sur 30 ans, de 1971 à 2000, calculées à partir de données obtenues auprès de Météo France, mesurée à la station du Raizet, la plus proche de la lagune de la Manche-à-Eau; motifs foncés: périodes d'échantillonnage à la roténone.

vegetal debris and decreased for copepods and eggs, mainly in 2003. IRI had different series of values for small (TL ≤ 42-46 mm) and large (TL > 42-46 mm) size classes. Polychaets found in May (Table 11) were present in the large sizes (50 ≤ TL ≤ 64).

The nutrition quality index NQ (Fig. 8) always decreased with size. The slopes of the linear regression of NQ as a function of size class (TL 2 mm) at each date were similar. The May 2003 value was situated above that of February 2002. Y intercept was 58.8 in 2002 and 65.2 in 2003. NQ was higher (Fig. 9) in small size classes (TL ≤ 46 mm) than in large ones (TL > 46 mm).

Table 10. *Lophogobius cyprinoides.* February 2002 variations of the index of relative importance IRI, in Log_{10} (IRI), of prey items with size class (2 mm in total length TL); n: number of items; N: number of individuals samples. Veg. Deb.: vegetable debris; An. Deb.: animal debris; Foram.: foraminiferae; Ostrac.: ostracods; Copep.: copepods; Amphip.: amphipods; Isop.: isopods; Decap.: decapods; Crustac.: crustaceans; Non id.: non identified.

Tableau 10. *Lophogobius cyprinoides.* Variations en février 2002, de l'indice d'importance relative IRI, en Log_{10} (IRI), des diverses catégories de proies selon la classe de taille (TL = 2 mm) ; n : nombre d'items ; N : nombre d'individus échantillonnés ; Veg. Deb. : débris végétaux ; An. Deb. : débris animaux ; Foram. : Foraminifères ; Ostrac. : Ostracodes ; Copep. : Copépodes ; Amphip. : Amphipodes ; Isop. : Isopodes ; Decap. : Décapodes ; Crustac. : Crustacés ; Non id. : non identifié.

Item/TL	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	64	70
Veg. Deb.	2.2	3.3	3.1	3.3	3.8	3.5	3.5	3.7	3.5	4.0	3.7	3.7	3.7	3.3	4.1	3.9	4.1	3.9	3.8	4.0	4.0
Copep.	4.1	3.5	4.0	4.1	3.9	4.0	4.0	3.9	4.1	3.6	3.8	3.8	3.7	3.9	3.1	3.8	3.2	3.1	3.2	3.6	3.0
Eggs	2.8	3.2	2.9	2.5	2.1	2.9	2.7	2.8	2.7	3.3	3.0	2.7	2.7	3.0	2.4	3.0	2.8	2.7	-	3.0	-
Amphip.	2.4	3.4	2.9	2.9	3.4	3.1	2.9	2.9	2.9	3.2	3.1	2.7	3.6	3.5	3.3	3.4	3.1	3.6	3.6	2.9	3.7
Ostrac.	3.3	2.1	2.6	2.9	2.9	2.6	2.7	3.1	2.9	2.8	2.7	2.4	2.9	2.3	2.3	2.5	2.7	2.9	-	3.0	2.5
Decap.	2.1	2.4	2.0	2.7	2.9	2.4	2.7	2.2	2.6	1.9	2.4	1.3	1.9	1.9	2.7	3.0	2.4	2.6	-	2.8	2.9
Foram.	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	1.0	-	1.7	-	-	-
Nematods	2.5	2.5	1.8	2.0	1.5	2.3	2.2	2.5	2.5	2.8	2.9	2.2	2.6	2.5	-	2.4	2.7	2.5	-	-	-
Larvae	1.9	-	1.2	2.2	-	1.2	2.5	1.1	1.6	2.3	1.3	-	2.7	-	2.3	-	0.9	-	-	1.9	-
Bivalves	-	-	0.7	-	-	-	-	0.7	-	-	-	-	-	-	-	1.6	-	-	-	1.6	-
Isop.	-	2.4	1.4	-	1.7	1.8	1.4	1.9	1.3	0.9	2.5	1.3	-	1.9	2.5	3.0	2.9	3.4	3.3	2.1	2.9
An. Deb.	-	-	1.2	1.7	2.1	0.9	-	2.8	-	1.9	2.7	2.1	2.7	1.6	2.8	1.6	3.0	2.8	3.8	3.4	3.2
Non id.	-	-	-	-	-	-	-	-	-	-	-	1.7	1.7	-	-	-	0.9	-	-	-	-
Insects	-	-	-	-	-	-	-	-	-	0.6	-	-	-	-	-	-	0.9	-	-	-	-
Crustac.	-	2.4	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
n=15	**8**	**9**	**11**	**9**	**9**	**11**	**10**	**11**	**9**	**11**	**10**	**10**	**10**	**9**	**9**	**11**	**12**	**10**	**5**	**10**	**7**
N	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**3**	**4**	**2**	**4**	**4**	**2**	**1**	**2**	**1**

Discussion

The different types of fishing used in this study revealed that *L. cyprinoides* is difficult to capture, and that it does not move very much, otherwise a higher number of specimen should have been found in boxtraps, and a higher occurrence of observation of the species by diving should have happened. This species is not gregarious and prefers to shelter near mangrove roots rather than exploring the open depths. It is a very cryptobenthic species, relatively scarce compared to other "forage" atlanto-mediterranean species belonging to the same family such as *Pomatoschistus minutus* (Pallas, 1770) and *P. microps* (Krøyer, 1838).

From the two types of fishing tested, the most efficient one was rotenone compared to boxtraps, as the number of fish caught at a time and the catch per unit effort were greater. Further, the time to obtain specimen was longer with boxtraps than with rotenone.

The boxtraps baited with vegetable matter were an unsatisfactory solution, requiring much more effort than rotenone, yet resulting in much smaller samples. To get a better efficiency yield with boxtraps, it is suggested to use them in great number and to visit them very frequently, each three to four days at a study site not far from the laboratory. Rotenone resulted in sample sizes of 133 specimens in February 2002 and 533 in May 2003, implying that this species occupies more habitats than those just mentioned. The ecological niche of *L. cyprinoides* could explain the large difference in the number of specimen caught by both types of fishing. *Chromogobius quadrivittatus* (Steindachner, 1863) or *C. zebratus* (Kolombatovic, 1891) occupy the same type of ecological niche, without moving very much, as well as goby species of the *Pomatoschistus* or *Gobius* genus.

The maximum length observed (78 mm) was a male specimen. This value is smaller than the one observed in Venezuela, where the crested goby reach 100 mm (Cervigón, 1966). The largest female was 64 mm long. The difference of 14 mm between the maximum size of females and males suggests sexual dimorphism; the males are systematically larger. If growth of the crested goby is isometric for both sexes, then the variation observed between February and May in the mass-length relationship might indicate a stage of relative stoutness.

The average size differences between the February 2002 and May 2003 samples reveal that the smaller individuals have grown. Though the sampling periods do not correspond to a same year, the February 2002 sampling occured during the full dry season (Fig. 9) and the one of

Table 11. *Lophogobius cyprinoides*. May 2003 variations of the index of relative importance IRI, in Log_{10} (IRI), of prey items with *L. cyprinoides* size class (2 mm in total length TL); n: number of items; N: number of individuals sampled.

Tableau 11. *Lophogobius cyprinoides*. Variations en mai 2003, de l'indice d'importance relative IRI, en Log_{10} (IRI), des diverses catégories de proies selon la classe de taille (TL = 2 mm) de *L. cyprinoides* ; n : nombre d'items ; N : nombre d'individus échantillonnés.

Item/TL	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	64	66	70	74
Vegetable Debris	-	3.2	3.4	3.6	3.7	3.8	3.8	4.0	4.2	4.0	4.1	4.2	4.1	4.2	4.2	4.1	4.2	4.1	4.1	4.3	4.2	4.2	4.2	4.2	4.2	4.1
Copepods	3.7	4.0	4.0	3.7	3.9	3.7	3.9	3.8	3.6	3.5	3.6	3.1	3.6	3.1	3.3	3.3	3.2	2.7	3.4	3.0	3.1	3.1	3.5	3.2	2.7	3.3
Eggs	2.3	2.8	3.4	3.1	3.2	2.7	3.2	3.1	2.0	1.1	2.9	1.9	2.1	2.0	2.7	2.4	-	2.4	1.0	1.5	2.4	2.5	1.5	-	-	-
Amphipods	-	2.6	2.4	3.2	2.9	2.5	2.4	1.8	2.4	2.7	2.2	1.1	2.3	1.8	2.1	2.3	2.0	1.9	2.2	2.0	2.6	2.2	2.6	2.0	3.3	-
Ostracods	-	2.2	2.8	2.1	2.5	3.0	3.0	3.0	2.2	2.1	1.7	0.7	1.6	-	1.9	1.7	1.7	1.1	1.8	1.8	1.7	-	-	1.9	2.2	-
Decapods	-	-	2.5	2.4	1.7	-	1.5	1.8	2.0	1.6	2.2	1.4	2.5	1.3	1.2	2.1	2.3	1.6	2.1	2.0	1.8	1.4	2.1	2.8	2.5	3.1
Foraminiferae	2.3	1.8	2.3	2.4	1.6	0.9	2.3	2.7	2.5	2.4	1.9	1.7	1.9	0.6	1.5	1.7	1.8	1.5	1.0	1.7	-	1.0	2.1	1.6	-	-
Nematods	2.5	1.9	-	1.9	2.1	2.6	1.2	-	1.8	2.2	2.3	2.2	2.3	2.1	1.8	2.0	1.4	1.4	1.7	2.2	-	-	-	-	2.4	-
Larvae	-	1.6	2.4	2.1	2.9	1.8	2.2	1.9	2.1	-	1.5	1.5	2.0	1.1	1.0	-	-	2.0	1.3	-	-	-	-	1.8	-	-
Bivalves	-	-	1.1	1.9	2.1	0.9	1.9	1.0	1.5	2.1	1.4	1.4	2.1	2.2	0.7	1.9	1.2	1.3	1.0	-	-	2.0	1.4	-	-	-
Isopods	-	3.1	2.4	1.8	-	-	1.5	1.8	1.2	-	1.1	-	1.9	-	1.2	-	1.6	1.0	-	1.3	1.8	-	-	-	-	2.8
Polychaets	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.1	1.4	-	-	2.3	1.9	2.0	-	-	-
Cumaceans	-	2.8	-	2.0	-	-	-	-	-	-	-	1.8	-	-	1.3	-	-	-	-	-	-	-	-	-	-	-
Animal Debris	-	-	-	-	-	-	-	1.0	-	1.4	-	-	-	-	-	-	1.3	0.8	1.3	1.4	-	1.8	-	-	-	-
Non identified	2.3	1.2	1.0	-	-	-	-	-	0.7	-	-	-	0.6	-	-	-	-	-	-	-	-	0.9	-	-	-	-
Insects	-	-	2.1	-	-	-	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
n=16	**5**	**11**	**12**	**12**	**10**	**9**	**12**	**11**	**12**	**10**	**11**	**11**	**12**	**9**	**12**	**9**	**11**	**13**	**11**	**10**	**8**	**10**	**8**	**7**	**6**	**4**
N	**2**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**2**	**3**	**3**	**2**	**1**	**1**

May 2003 during the intermediary humid season, before the cyclonic season (July to October).

The differences between the two size-class histograms can be explained by enhanced mortality among fish of 42 mm or more (as seen in the decrease of the relative abundance in the upper size classes), growth of the surviving population, recruitment of juveniles (18-25 mm), and coming out of a few aged specimens reaching length above 72 mm. According to the condition index K_c, the average stoutness of fish is greater during the intermediary season (May) than the dry season (February). The growth and the better condition of fish observed in the May sample could be related to the oncoming rainy, humid and warmer season (Fig. 9), enriching the brackish water in nutrient and the lagoon productivity. The great condition index observed in May could be explained by newly recruited individuals, not yet engaged in the reproductive effort and focusing their energies entirely on somatic growth.

Although males were present in all size classes, those between 18 and 42 mm were well feminized. For size class > 42 mm, males were more common, and the population was completely masculinized from 72 mm onward. The heavy feminization of the principal age classes (3 to 4 females per male) and the complete masculinization of the largest specimens suggest that the species practices sexual inversion and protogynous hermaphrodism. On a single female specimen, Cole (1990) observed, without formally affirming it, structures similar to pAGS (precursors of accesory gonad structures) associated to the ovary. A histological examination of the ovaries in individuals between 46 and 68 mm could reveal if preformed testicular tissue is present in the germinal tissue. The possible protogynous hermaphrodism suits well with the cryptic characteristic of the crested goby, favoring chances for both sexes to meet and increasing their reproductive success, while sizes (TL) at first maturity are small (35 mm for females, 40 mm for males).

The activation of gonadic maturity in *L. cyprinoides* takes place from January to July, and also in November. The reproductive period therefore extends over a large portion of the year, from January to November; particular rapid gonadic maturation is recorded between February and

July. The number of ovaries mass data was too small to test any statistically significant variations in the gonadosomatic index. The small number of almost ripe ovocytes (7-15) counted among the initial lot of ovocytes in three specimens at stage IV implies that the females fecundity is very low and that this short-lived species is iteroparous (biennial). The sub-cryptobenthic nature of the species makes it very difficult to obtain the complete samples necessary for an exhaustive study. Nevertheless, our observations have brought new insights into their mode of reproduction.

L. cyprinoides is a species whose diurnal trophic activity during the summer was demonstrated by an experimental fishing technique using rotenone in broad daylight, four to five hours after the sunrise. Its hidden way of life, mainly beneath the mangrove roots in the shadow, forces it to look for easy prey at times when luminosity is high. A different nychtemeral rhythm among the dominant species in the fish assemblage of the Manche-à-Eau lagoon gerreids (*Diapterus rhombeus, Eucinostomus argenteus, E. gula*) and scianid *Bairdiella rhonchus* was pointed out (Bouchereau & Chantrel, 1999). This opposition suggests a resource share and/or a different anti predation strategy. The three dietary indices used in the present study, combined in the index of relative importance, confirm that *L. cyprinoides* is an omnivorous species, specialized in vegetable debris and copepods. Independantly of the dietary indice used, we observed a tendency of increasing herbivorous behaviour with size. However, a difference can be noticed in the diet of small (≤ 46 mm) and large individuals with the numerical and point frequencies. Among small specimens, copepods are the dominant food source; this trend fades among the larger fish, as they diversify their diet spectrum with the index of relative importance per item. The importance of vegetable in the diet of *L. cyprinoides* in the Caribbean Sea is not as high as in Florida (Darcy, 1981), and copepods and the other items of the diet spectrum are more frequently caught in Guadeloupe than in Florida. Diet activity is more important in May than in February, in regards to the degree of fullness and the nutritional quality. The latter shows that small size (18 to 46 mm) individuals have a better nutritional quality at that period than the larger ones (46 to 78 mm). This change of diet with size and season was already observed by Bodiou & Villiers (1979) with the Gobiidae *Deltentosteus quadrimaculatus* (Valenciennes, 1837). Bone et al. (1995) noted that copepods are an ideal resource for fish larvae. Miller (1986) remarked that the Gobiidae consume mainly invertebrates, as shown in the Mediterranean by Joyeux et al. (1991) for *Gobius niger* and by Bouchereau & Guélorget (1999) for *Gobius bucchichi* Steidachner, 1870 and *Millerigobius macrocephalus* (Kolombatovic, 1891). However, *L. cyprinoides* might claim the status of herbivorous as well as first-order carnivorous. Vegetable debris and copepods are the food items most frequently ingested by adults, and suffice to meet their physiological needs.

The question that arises is whether vegetable debris is a food source in its own right, or simply material accompanying a more specific prey such as Archaea. In our study, we did not look for Archaea in the digestive tracts, because Archaea had not yet been observed in this milieu. This question therefore remains opened. However, we note that the quality of nutrition is higher among small individuals (≤ 46 mm) who consume more biomass. This can be explained by the fact that more energy is needed to sustain their somatic growth (Miller, 1979). The size of 46 mm seems to be a pivotal point in the biology of *L. cyprinoides*, marking a change in diet in response to new requirements such as reproductive investment. In females, this change is a first-order effort (producing gametes and laying eggs); among male Gobiidae, the reproductive effort is secondary and linked to mating displays, protecting nest, guarding clutch, and oxygenating and cleaning eggs (Miller, 1984).

According to our observations, *L. cyprinoides* is a small territorial species that moves about very little and occupies a very cryptic ecotope. Its adaptation to the lagoon milieu and especially the mangrove habitat allow us to classify it as a sedentary species among the rare others. The observation of nests with guarding males should confirm this hypothesis as it was shown by Bouchereau et al. (1991) for other sedentary gobies. This could allow us to characterize the structure of laying substrates, evaluate the nesting fecundity of the species, and compare this result to the ovocyte fecundity of the female *L. cyprinoides*.

Diet is one of the aspects treated in the present study which let yet some outstanding questions. In this study, we focussed on the amount of food ingested, but the quality of the food in terms of chemical composition and its influence on the nutritional condition should also be considered. It could also be interesting to compare feeding differences among sexes and relate this to nutrition quality and/or selective behaviour among sexes.

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