Knowledge and Management of Aquatic Ecosystems (2009) 393, 04 http://www.kmae-journal.org

DOI: 10.1051/kmae/2009018

Food composition and zooplanktonic prey selectivity of *Lates niloticus* (Linné, 1762) juveniles in fishponds (Ivory Coast; West Africa)

N.C. Kouassi[(1)], K.Y. Bony[(2)], F.K. Konan[(2)], E.O. Edia[(2)], S. Sylla[(3)], J. Moreau[(4)]

Received August 10, 2009 / Reçu le 10 août 2009
Revised November 19, 2009 / Révisé le 19 novembre 2009
Accepted November 23, 2009 / Accepté le 23 novembre 2009

ABSTRACT

Key-words: Lates niloticus, *juvenile, fish diet, pond, Ivory Coast*

Prey selectivity of juveniles of *Lates niloticus* was studied by looking at stomach contents of 570 fishes collected from a pond. Zooplankton was also sampled. The results were analysed using the Self-Organising Map and the graphical method of Costello (1990) [*J. Fish Biol.*, *36*, 261–263] modified by Amundsen *et al.* (1996) [*J. Fish Biol.*, *48*, 607–614]. Preys, comprising 38 taxa, were predominantly zooplankton (rotifers and copepods). The abundance of prey did not regulate food selectivity and prey size represented a limiting factor for the use of food resources. *Lates niloticus* juveniles were clearly specialised in copepods but occasionally included small proportions of other prey types (rotifers, ostracods, insects and fishes) in their diet. They foraged at this stage according to the Optimal Foraging Theory. Food preference is affected by the accessibility, motility and energy content of food items.

RÉSUMÉ

Composition alimentaire et séléctivité des proies zooplanctoniques chez les juvéniles de *Lates niloticus* (Linne, 1762) en étang de pisciculture (Côte d'Ivoire ; Afrique de l'Ouest)

Mots-clés : Lates niloticus, *juvénile, régime alimentaire, étang, Côte d'Ivoire*

La sélectivité des proies chez les juvéniles de *Lates niloticus* a été étudiée en observant les contenus stomacaux de 570 poissons récoltés dans un étang. Le zooplancton disponible dans le milieu a également été observé. Les résultats ont été analysés à l'aide du réseau de neurone non supervisé (Self Organising Map) et de la méthode graphique de Costello (1990) [*J. Fish Biol.*, *36*, 261–263] modifiée par Amundsen *et al.* (1996) [*J. Fish Biol.*, *48*, 607–614]. Les proies constituées de 38 taxons sont dominées par le zooplancton (rotifères et copépodes). Les abondances n'influencent pas la sélectivité des proies et la taille constitue un facteur limitant dans l'utilisation des ressources alimentaires. Les juvéniles de *Lates niloticus* apparaissent clairement spécialisés dans la consommation des copépodes mais incluent occasionnellement de faibles proportions d'autres proies (rotifères, ostracodes, insectes et poissons). Cette espèce se nourrit à ce stade conformément à la théorie du « Optimal Foraging ». La préférence alimentaire dépend de l'accessibilité, la mobilité et l'énergie contenue dans les proies.

(1) Centre National de Recherche Agronomique (CNRA), Programme Pêche et Aquaculture Continentales (PPAC), 08 BP 33 Abidjan 08, Côte d'Ivoire
(2) Laboratoire Environnement et Biologie Aquatique (LEBA), UFR-Sciences et Gestion de l'Environnement, Université d'Abobo-Adjamé, 02 BP 801 Abidjan 02, Côte d'Ivoire, bonyves@yahoo.fr
(3) Centre de Recherches Océanologiques (CRO), Département Aquaculture, BP V 18 Abidjan, Côte d'Ivoire
(4) Laboratoire d'Écologie Fonctionnelle, UMR 5245 CNRS/UPS/INPT ENSAT, Avenue de l'Agrobiopole, BP 107 Auzeville Tolosane, 31326 Castanet Tolosan, Toulouse, France

Article published by EDP Sciences

INTRODUCTION

In the Ivory Coast, the enormous volume of water resources (500 km of marine coast, numerous rivers, artificial lakes and dams) plays a great role in the modern economic development. Nevertheless, this significant hydrological potential does not cover the population's nutritional needs as regards aquatic animal proteins. The deficit was estimated at about 180 000 tons per year (FAO, 1999), and hence aquaculture was adopted as a tool in rural food security and economic development.

The development of scientific research programmes and the introduction of fish farms are alternatives to reduce the country's food demands. *Oreochromis niloticus* was firstly identified to be more adapted to rearing. Later on, other species such as *Chrysichthys nigrodigitatus*, *Heterobranchus longifilis* and *Sarotherodon melanotheron* were popularised. Several studies were conducted in order to diversify the rearing species. To achieve that goal, species that show the best aquacultural characteristics such as a high growth rate, resistance to management and diseases, a good food conversion rate, single nutritional requirements, and omnivorous feeding habits need to be selected (Martinez-Cordova, 1999).

The main species investigated was *Lates niloticus*, the only freshwater species of the Centropomidae family present in West Africa (Lévêque *et al.*, 1992). This species is very appreciated by the African population because of its high gastronomic value and its flesh's high quality. It was well documented after its introduction into Lake Victoria (Fryer, 1960; Barel *et al.*, 1985; Ogutu-Ohwayo, 1990, 1993, 2004; Mkumbo and Ligtvoet, 1992; Schofield and Chapman, 1999). Moreover, this species has a high growth rate. A research programme conducted in the Station de Recherche en Pisciculture of the Centre National de Recherche Agronomique (CNRA, Côte d'Ivoire) led to the control of its reproduction in fishponds. Also, other studies were developed concerning this fish's diet and feeding habits. The limiting factor in the spread of *L. niloticus* farming is the seed availability. Now our attention is focused on the massive production of juveniles and development of technology for rearing of seedlings. Previous works of Hopson (1972) and Katunzi *et al.* (2006) have shown that the food items preferred by larvae of *L. niloticus* were zooplankton. According to Hopson (1972), juveniles between 20 and 300 mm feed mainly on planktonic crustaceans and aquatic insects. Katunzi *et al.* (2006) showed that the diet of Nile perch shifted from zooplankton and midge larvae, to macro-invertebrates (shrimps and dragonfly nymphs) and fish in Lake Victoria. At a size of 3–4 cm Nile perch shifted from size-selective predation on the largest cyclopoids to predation on the largest, less abundant calanoids.

The aim of this study is to discover if all prey items (zooplankton and aquatic insects) at different sizes have the same trophic importance in the diet of juveniles in ponds by evaluating food composition and prey selectivity.

MATERIAL AND METHODS

> *BIOLOGICAL MATERIAL SURVEY*

A total of 812 juvenile fishes aged 30 to 79 days were obtained by natural reproduction of 12 adults (8 males and 4 females) in four 400-m^2 fishponds (depth range: 1 to 1.5 m) and stored in a 175-m^2 fertilised pond.

Samples of minimum 30 specimens were collected weekly at random with a net for seven weeks. Each specimen was measured (standard length) to the nearest 1 mm. They were carefully dissected and stomachs were removed and preserved in 4% formalin until analysis.

The study of stomach contents was completed by an analysis of food availability. Thus, zooplankton was collected with an Apstein plankton net (mesh size 40 μm) by doing horizontal tows over 14 m, except in the first week. Zooplankton samples were preserved with 4% formalin solution.

In the laboratory, we used a total of 570 non-empty stomachs of juveniles of *Lates niloticus* (mean length 27.3 ± 0.6 mm) to assess diet. Stomachs and intestinal contents were investigated. The gut contents were diluted in 10 mL water, and gut contents were observed under an inverted microscope using a gridded Petri dish. Because the different prey taxa occurred in pieces of different sizes, biomass could not be quantified. Therefore, gut content was presented as proportions of counted food items, which were classified into several groups. Identification of zooplankton was based on the mandible, furca, post-abdominal claw and exoskeleton structure. They were identified to the lowest taxon possible, genus or species level, following Dussart (1966), Ruttner (1974) and Rey (1986).

FOOD AVAILABILITY

The study of stomach contents was followed by an analysis of food availability by sampling zooplankton, which is the main food item in *L. niloticus* juveniles' diet. Zooplankton abundance in the pond was determined by counting 1-mL sub-samples under a microscope. Species were classified into groups according to the same prey categories in guts. However, the zooplankton composition in the lake was not determined in the seventh week.

DATA ANALYSES

> NON-PARAMETRIC ANALYSIS

To compare zooplankton densities in the pond, the Kolmogorov-Smirnov test was first applied to check normality in the distribution of data. And accordingly, the Kruskal-Wallis ANOVA and the Mann-Whitney U-test were performed using the STATISTICA 7.1 computer package to test for significant differences between main groups and temporal distribution (over all weeks) of zooplankton densities among each group.

> STOMACH CONTENT ASSEMBLAGES USING A SELF-ORGANISING MAP (SOM)

The distribution pattern of fishes was displayed using the Self-Organising Map (SOM) by means of the toolbox developed by Alhoniemi *et al.* (2003) for Matlab®. First, a prey's occurrence data set was arranged as a matrix of 89 rows (*i.e.*, the non-empty stomachs) and 29 columns (*i.e.*, the prey's species). Each of the 89 samples of the data set can be considered as a vector of 29 dimensions. Then, the species occurrence data set was patterned by training the SOM. The architecture of the SOM consisted of two layers of neurons (or nodes): (i) the input layer was composed of 89 neurons connected to each vector of the data set, and (ii) the two-dimensional output layer was composed of 49 neurons (*i.e.* a rectangular grid with 7 by 7 neurons laid out on a hexagonal lattice). We chose a 49-neuron grid because this configuration presented minimum values of both quantisation and topographic errors, which are used to assess classification quality (*e.g.* Kiviluoto, 1996; Kohonen, 2001; Park *et al.*, 2003). The SOM algorithm calculates the connection intensities (*i.e.* vector weights) between input and output layers using an unsupervised competitive learning procedure (Kohonen, 2001), which iteratively classifies samples in each node according to their similarity in species composition. Thus, the SOM preserves the neighbourhood so that samples with close species occurrences are grouped together on the map, whereas samples with very different species occurrences are far from each other.

We checked whether relevant groups of samples characterised distinct prey assemblages by performing a hierarchical cluster analysis (Ward's linkage and Euclidean distance). To do so, we used a new matrix (49×29, output neurons $\times$ species) of the connection intensity values estimated by the SOM.

Between-cluster differences in species occurrences were evaluated using the Kruskal-Wallis test, a non-parametric analysis of variance, followed by the Mann-Whitney test to identify specific differences.

The relationships between fish samples associated with each cluster and the factors of the regrouping (fish age and class size), which were not used in the SOM learning process, were assessed. To do so, we calculated for each cluster the relative contribution of each modality (*e.g.*, fish age) of a certain factor (*e.g.*, class size) to the total number of modalities of the factor. Then, we tested for the H_0 that no significant differences were present among these relative values using a test for proportions (G-test) based on the likelihood ratio χ^2 statistics (Sokal and Rohlf, 1995; Sachs, 1997). Statistical calculations were performed using R (Ihaka and Gentleman, 1996).

> *FEEDING STRATEGY*

The Costello method modified by Amundsen *et al.* (1996) was used to discuss the variation in feeding strategy. Costello's (1990) analysis is based on a two-dimensional representation, where each point represents the frequency of occurrence and the abundance of a prey taxon. Costello suggested that the two diagonals of the plot represent prey importance (dominant-rare) and predator feeding strategy (specialisation-generalised). In an attempt to overcome the problems inherent in the Costello method, Amundsen *et al.* (1996) suggested that a new parameter, the prey-specific abundance (*Pi*), is incorporated into the graphical representation of dietary composition. Prey-specific abundance is defined as the percentage comprised by a prey taxon of all prey items in only those predators in which the actual prey occurs, or in mathematical terms:

$$Pi = \left(\sum S_i / \sum St_i\right) \times 100$$

where *Pi* is the prey-specific abundance of prey *i*, *Si* the stomach content (volume, weight or number) comprised of prey *i*, and *Sti* the total stomach content in only those predators with prey *i* in their stomach.

In the new graphical presentation, the prey-specific abundance is plotted against the frequency of occurrence on a two-dimensional graph. This resembles the Costello plot, but prey-specific abundance is used instead of percentage abundance. The product of prey-specific abundance and frequency of occurrence (expressed as a fraction rather than in percent) equals the prey abundance, provided that the average amount of stomach contents is independent of the prey categories consumed, or that the amount of food in each stomach is standardised to equality (*i.e.* to 100%) before abundance estimates are made. Therefore, for each point on the graph, the prey abundance is represented by the area enclosed by all the co-ordinates of the two axes. The sum of the areas for all prey types will equal the total area of the diagram (= 100% abundance). Furthermore, any combination of prey-specific abundance and frequency of occurrence equals a certain prey abundance, and different values of prey abundance can be represented by isopleths on the graph.

RESULTS

> *FOOD AVAILABILITY*

The zooplankton community in the pond, comprising 38 taxa, was represented by Rotifers (24 species), Cladorerans (9 species) and copepods (5 species). We also identified Ostracods and aquatic insects in the samples. The total density of zooplankton showed a drastic reduction over the sampling period (1800 ind$\cdot$L^{-1} at the beginning to 126.1 ind$\cdot$L^{-1} at the end) (Figure 1A). Rotifers formed the principal part of the community during the first (95%), second (57.8%) and fifth (65%) weeks, whereas copepods appeared mainly in the pond in the third (64.3%), fourth (61.6%) and sixth (61%) weeks (Figure 1B). Cladocerans, Ostracods and aquatic insects represented less than 1% of total density (Figure 1B).

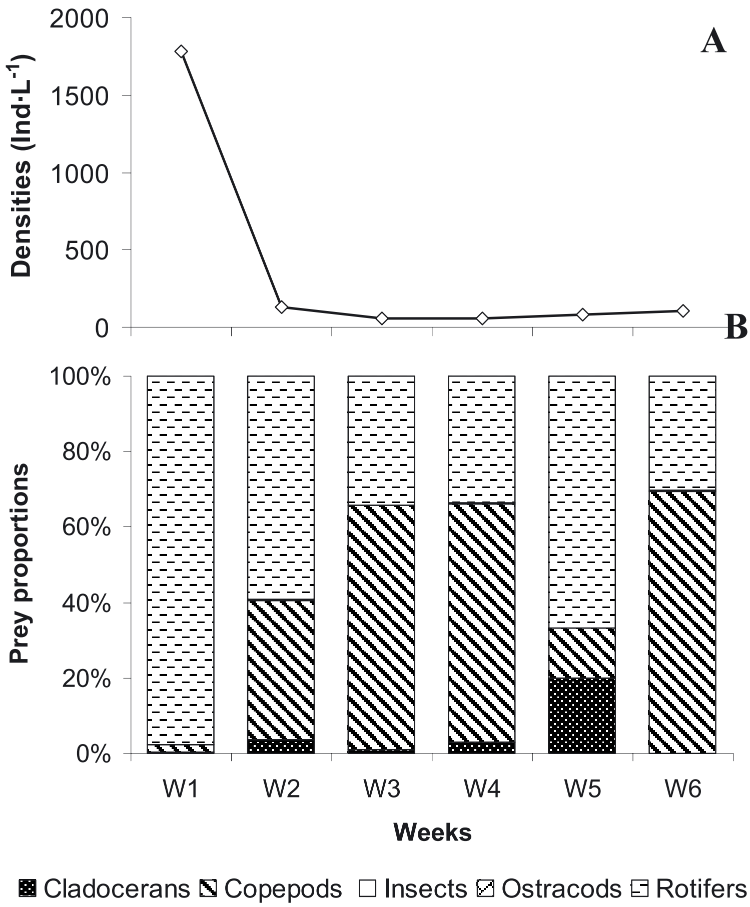


Figure 1
Density trends (A) and percentage composition (B) of zooplankton in the pond.

Figure 1
Variation des densités (A) et proportions (B) du zooplancton dans l'étang.

> COMPOSITION OF DIET USING SOM

Stomach contents of 570 juveniles collected over seven weeks were examined. The results (SOM map) showed five clusters (A; B1 and B2; C; D; E) of samples at different levels of the Euclidean distance (Figure 2). The sample distribution pattern classification was related to the fish's size and temporal factors. The G-test showed that clusters B, D and E were grouping according to the sampling date criterion. Thus, clusters B and D were, respectively, composed solely of samples of the sixth and second weeks. Cluster E was mainly composed of the fifth week's samples. On the other hand, clusters were grouped according to fish size. Clusters A and B were almost entirely made up of fishes over 30 mm, while clusters C, D and E were mainly characterised by fishes of less than 30 mm (Figure 3).

Table I shows the contribution of each prey item in the composition of the diet of fishes (samples) on the SOM map. The next step is to compare the relationship among clusters of samples and the distribution of prey items. Thus, cluster A is related to a cladoceran (*Alona monacantha*); insect adults and fish. Cluster B was characterised by *Chydorus sphericus* and *Moina micrura* (cladocerans), and copepodites. Cluster C was made up of copepods (*Thermocyclops consimilis*), *Simocephalus serrulatus* (cladoceran), and Ostracods. Cluster D was represented by cladocerans (*Ceriodaphnia affinis* and *C. cornuta*); a copepod (*Thermodiaptomus yabensis*), a rotifer *(Lecane* sp.), copepodites and insect larvae. Cluster E was

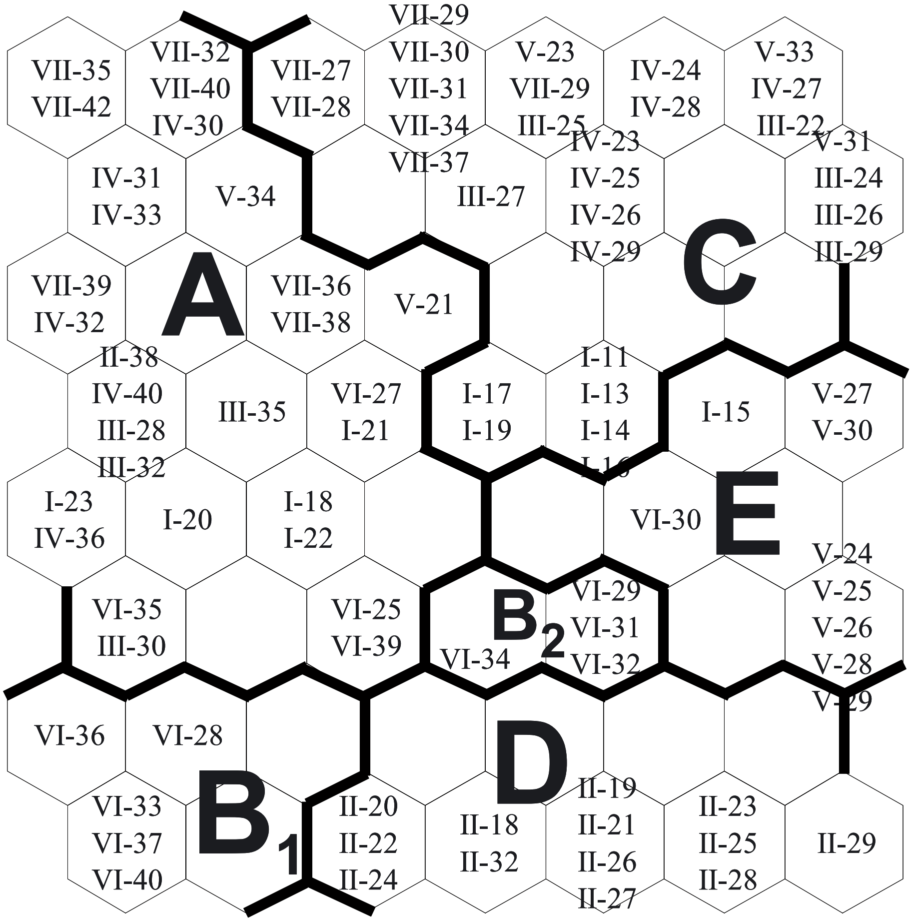


Figure 2
The map obtained by SOM for patterning fishes with stomach contents reported from the pond. The letters (A, B, C, D and E) represent different clusters. The acronyms in the hexagonal units represent different samples (sampling date in Latin numbers and arabic numbers for fish size).

Figure 2
Distribution des échantillons dans la carte auto-organisatrice à partir des contenus stomacaux des juvéniles de *Lates niloticus* en étang. Les lettres (A, B, C, D et E) représentent les différents groupes. Les acronymes dans les cellules représentent les différents échantillons (les chiffres romains font référence aux dates d'échantillonnage et les chiffres arabes font référence à la taille des individus).

related to copepods (*Thermocyclops decipiens; Mesocyclops*), and *Ceriodaphnia cornuta, Diaphanosoma excisum* and *Macrothrix triserialis* (cladocerans).

> *FEEDING STRATEGY*

Figure 4 shows the evolution of the feeding strategy of *L. niloticus* juveniles according to the Costello method. The population of seedlings is clearly specialised in copepods (located at the upper right of the diagram) during our study period, except at the end of the experiment. Thus, in the sixth week, cladocerans were the main item in their diet, and in the seventh they became generalist. Moreover, small proportions of other prey types (rotifers, ostracods and fishes) were occasionally included in the diet of some individuals, and insects had been eaten occasionally by most individuals.

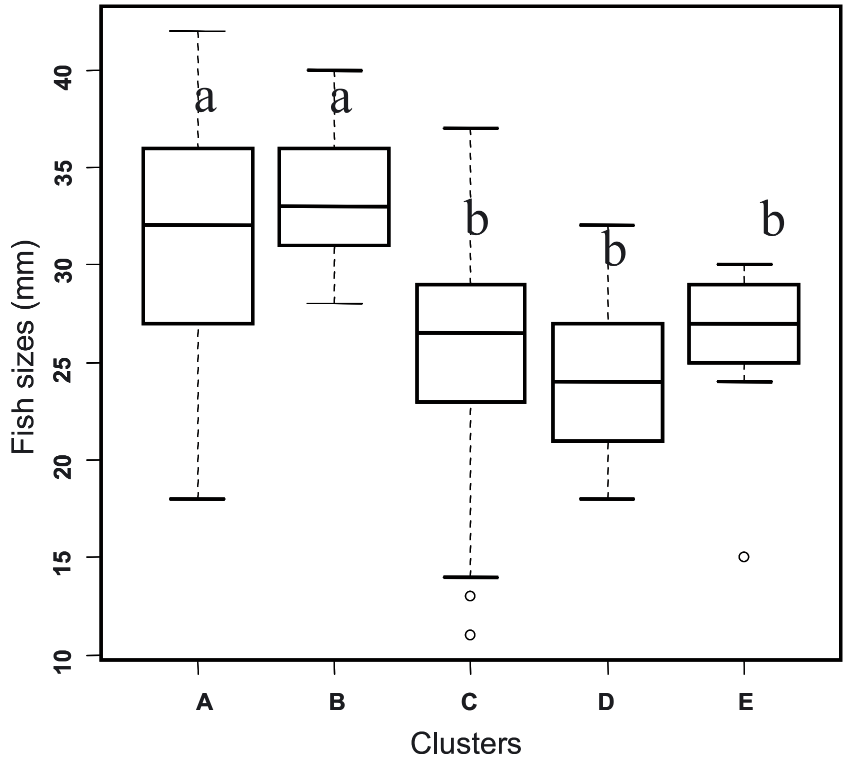


Figure 3
Boxplots comparing fish size in different clusters. The different alphabets indicate significant difference in the Mann–Whitney test (p < 0.05).

Figure 3
Boîtes à moustaches comparant la taille des poissons dans les différents groupes. Les différentes lettres indiquent le niveau de significativité du test de Mann-Whitney (p < 0,05).

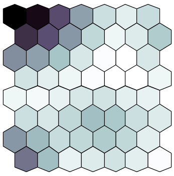
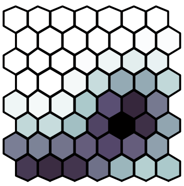
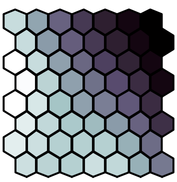
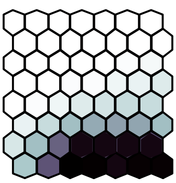
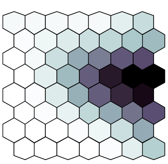
DISCUSSION

Our results show that preys were more abundant in the 175-m^2 pond during the first week, and their density decreased heavily in numbers after the introduction of the juveniles. The high abundance of zooplankton at the beginning of the experiment is explained by high availability and diversity of food linked to the fertilisation. Indeed, zooplankton feed upon phytoplankton, which is well developed after the use of dried organic fertilisers (Lanoiselee, 1984). Also, the principal cause of the decline in density was the predation by juvenile fishes, which strongly influence composition and abundance of zooplankton populations.

Similar to the finding of Bonou (1990) in a pond and Ouéda *et al.* (2008) in Lonmbila lake, rotifers were consistently the most abundant component of zooplankton, and appeared earliest in the pond. This corroborates that *Lates niloticus*, which generally do not feed on ostracods (Hopson, 1972; Loiselle, 1972; Assi, 1989), were found to feed on them when other preferred preys were absent. Juvenile feeding, however, did not strictly reflect zooplankton availability in the pond. In fact, preys such as *Ceriodaphnia cornuta, Ceriodaphnia affinis, Simocephalus serrulatus, Alona monacantha* and *Chydorus sphericus*, copepods (*Thermodiaptomus yabensis*), and ostracods, relatively less observed in the pond, appeared abundantly in the diet of the juveniles. On the other hand, rotifers, and *Moina micrura* and *Diaphanosoma excisum* were not preyed upon regardless of their high density. This finding is not corroborated by the literature data, which revealed that prey density was important in determining diet composition of juveniles of *Salmo salar* (Tonney and Gibson, 1989) and in the food intake and diet composition of three native fish species of the Macintyre River (Medeiros and Arthington, 2008). Angermeier (1982) noted that fluctuations in the availability of food type may affect all

Table I
Distribution patterns of prey species in each cluster defined by the hierarchical clustering applied to the self-organising map (SOM) units. Dark represents high probability of occurrence, and light indicates lower probability.

Tableau I
Patron de distribution des espèces proies dans chaque groupe défini par la classification hiérarchique appliquée aux cellules de la carte auto-organisatrice. La couleur sombre représente les fortes probabilités d'occurrence ; la couleur claire représente les faibles probabilités d'occurrence.

Clusters	Taxa
Cluster **A** 	*Alona monacantha*; adult insect; fish
Cluster **B** 	Copepodites; *Chydorus sphericus*; *Moina micrura*
Cluster **C** 	*Thermocyclops consimilis*, *Simocephalus serrulatus*; Ostracods
Cluster **D** 	Copepodites, *Ceriodaphnia affinis*; *C. cornuta*, *Thermodiaptomus yabensis*; *Lecane* sp.; insect larvae
Cluster **E** 	*Thermocyclops decipiens; Mesocyclops*; *Ceriodaphnia cornuta*; *Diaphanosoma excisum*; *Macrothrix triserialis*

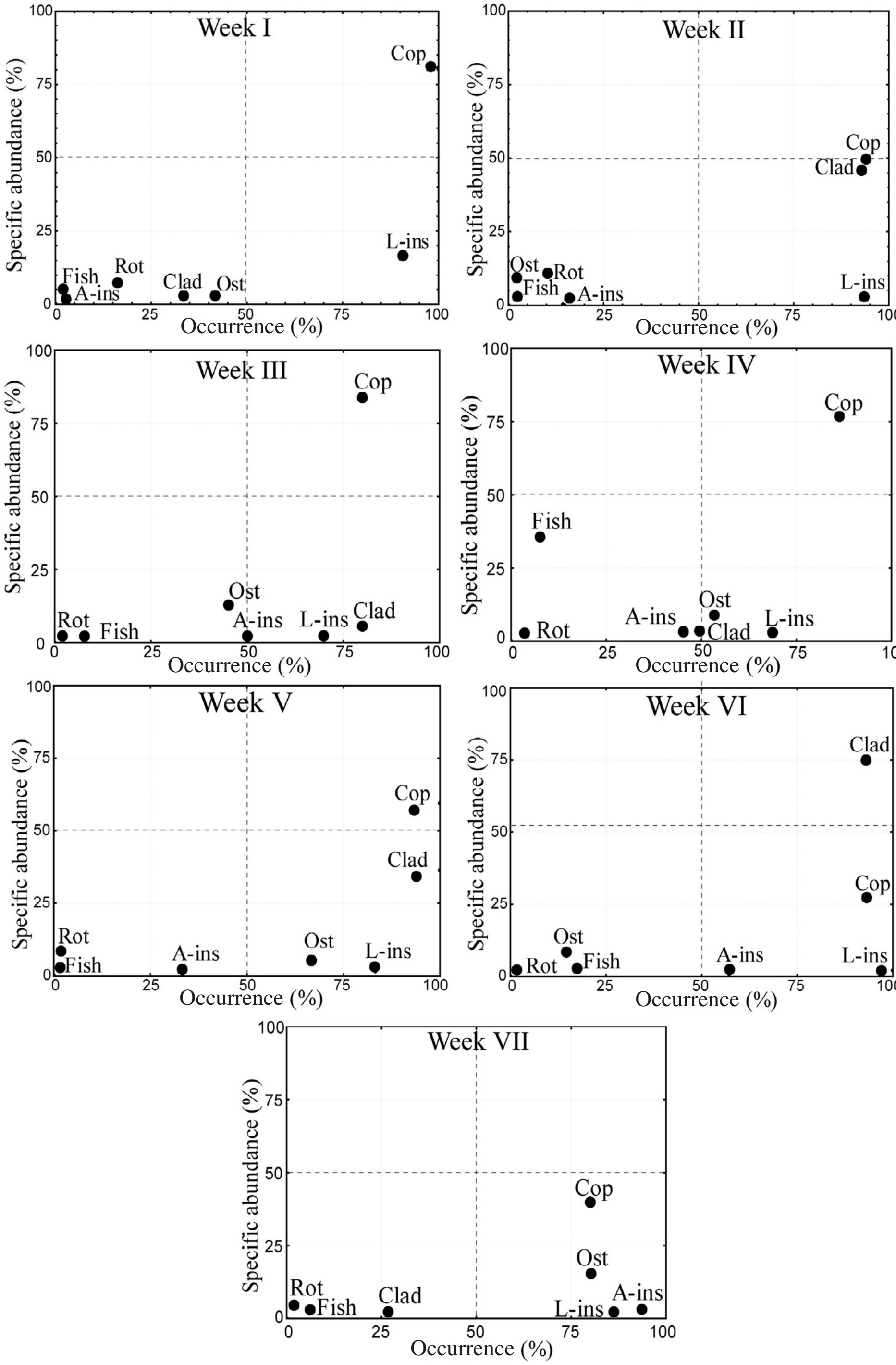


Figure 4
Feeding strategy diagrams. Prey importance and niche contribution of Lates niloticus *juveniles in the study period. Specific abundance against frequency of occurrence of food items (A-ins: Adult insects, Clad: Cladocerans, Cop: Copepods, Fish: Fish, L-ins: insect larvae, Ost: Ostracods, Rot: Rotifers).*

Figure 4
Diagrammes de la stratégie alimentaire. Importance des proies et contribution des niches des juvéniles de *Lates niloticus* durant la période d'étude. Abondance spécifique en fonction des occurrences des proies (A-ins : Adultes d'insectes, Clad : Cladocères, Cop : Copépodes, Fish : poisson, L-ins : larves d'insectes, Ost : Ostracodes, Rot : Rotifères).

foraging aspects and diet to some extent. The food selection of *L. niloticus* juveniles might be related to the size of copepods; they preferentially fed on large copepods when they were abundant (Rajasilta and Vuorinen, 1983). Female copepods with egg sacs which slow down their swimming speeds are vulnerable to fish predation. Also, the prey selection was found to change with fish size. *Simocephalus serrulatus* (Cladoceran) were the preferred food item of small fishes (less than 20 mm size), whereas large fishes (more than 30 mm size) mainly fed on Copepodites, *Alona monacantha*, adult insects and fish larvae. A similar pattern in dietary composition with fish size has also been reported by Katunzi *et al.* (2006), who noted that the proportion of the relatively large calanoids increased with fish size, and made up between 35 and 80% of the diet in Nile perch of 30–40 mm in Lake Victoria.

A similar pattern in dietary composition with fish size has also been reported by Diomandé *et al.* (2001) for *Synodontis bastiani* in the Ayamé man-made lake (Côte d'Ivoire). This shift in diet composition was linked to the size of food items: small fishes were found to eat small items, whereas larger fishes ate large items. It is well known that several factors such as prey size, availability, distribution, motility, vulnerability and its capacity to escape predators influenced the choice of prey items (Moore and Moore, 1976; Lauzanne, 1988; Stergiou and Fourtouni, 1991; Brewer and Warburton, 1992; Barry and Ehret, 1993).

Lates niloticus juveniles are specialised in copepods, though they did show minor variations in their diet at the end of the experiment. These observations agree with the findings of Prejs and Prejs (1987), and Pusey and Bradshaw (1996), who reported that changes were caused by changes in the availability of major food resources. The generalist feeding strategy is therefore favoured when food density is low or continuously fluctuating.

CONCLUSION

The present study showed that *Lates niloticus* found in the pond depend to a large extent on zooplankton, particularly copepods, as food at the juvenile stage. The rank of abundance of food items in the pond was different from that found in the guts of fishes. Food preference is very complex and affected by many factors such as the accessibility, motility and energy content of food items. Interestingly, fish shifted their diet during the study: consumption of and the contribution of cladocerans and insects increased slightly when consumption of main items decreased.

ACKNOWLEDGEMENTS

We are grateful to Ricardo Beldade (University of California) for improving the English in the manuscript.

REFERENCES

Alhoniemi E., Himberg J., Parankangas J. and Vesanto J., 2003. SOM Toolbox 2.0, Laboratory of Computer and Information Science, Neural Networks Research Center, Helsinki, Available at: http://www.cis.hut.fi/projects/somtoolbox/.

Amundsen P.A., Gabler H.M. and Staldvik F.J., 1996. A new approach to graphical analysis of feeding strategy from stomach contents data; modification of the Costello (1990) method. *J. Fish Biol.*, *48*, 607–614.

Angermeier P.L., 1982. Resource seasonality and fish diets in an Illinois stream. *Environ. Biol. Fish*, *31*, 389–401.

Assi K.C., 1989. Contribution à l'alevinage du *Lates niloticus* (Pisces : Centropomidae). Diplôme d'Études Approfondies d'Écologie Tropicale, Option Animale, Université Nationale Côte d'Ivoire, 51 p.

Barel C.D.N., Dorit R., Greenwood P.H., Fryer G., Hughes N., Jackson P. B.N., Kawanabe H., Lowe McConnell R.H., Nagoshi M., Ribbink A.J., Trewavas E., Witte F. and Yamaoka K., 1985. Destruction of fisheries in Africa's lake. *Nature*, *315*, 19–20.

Barry J.P. and Ehret M.J., 1993. Diet, food preference and algal availability for fishes and crabs on intertidal reef communities in southern California. *Environ. Biol. Fish.*, *37*, 82–92.

Bonou A.C., 1990. Étude de la productivité planctonique dans des étangs d'aquaculture en milieu saumâtre tropical. Identification et essais d'élevage de proies vivantes. Ph.D. Thesis, Institut national polytechnique de Toulouse, 232 p.

Brewer D.T. and Warburton K., 1992. Selection of prey from seagrass/mangrove environment by golden lined whiting, *Sillago analis* (Whitley). *J. Fish Biol.*, *40*, 257–271.

Costello M.J., 1990. Predator feeding strategy and prey importance: a new graphical analysis. *J. Fish Biol.*, *36*, 261–263.

Diomandé D., Gourene G. and Tito de Morais L., 2001. Stratégies alimentaires de *Synodontis bastiani* (Siluriformes : Mochokidae) dans le complexe fluvio-lacustre de la Bia, Côte d'Ivoire. *Cybium*, *25*, 7–21.

Dussart B., 1966. Les Copépodes des eaux continentales, Tome 1, Paris, N. Boubee et Cie, Faunes et Flores actuelles, 500 p.

FAO, 1999. The state of world fisheries and aquaculture 1998. Food and Agriculture organization of the United Nation, Rome.

Fryer G., 1960. Concerning the proposed introduction of Nile perch into Lac Victoria. *East Afr. Agric. For. J.*, *25*, 267–270.

Hopson A.J., 1972. A study of the Nile perch, *Lates niloticus* (pisces, Centropomidae) in lake Chad. *Overseas Res. Publ.*, *19*, 93.

Ihaka R. and Gentleman R., 1996. R: A Language for Data Analysis and Graphics. *J. Comput. Graph. Stat.*, *5*, 299–314.

Katunzi E.F.B., Van Densen W.L.T., Wanink J.H. and Witte F., 2006. Spatial and seasonal patterns in the feeding habits of juvenile *Lates niloticus* (L.), in the Mwanza Gulf of Lake Victoria. *Hydrobiologia*, *568*, 121–133.

Kiviluoto K., 1996. Topology preservation in self-organizing maps. *Proceedings of ICNN'96*, IEE International Conference on Neural Networks, IEEE Service Center, Piscataway, 294–299.

Kohonen T., 2001. Self-Organizing Maps, Springer Series in Information Sciences, Springer, New York.

Lanoiselee B., 1984. Fertilisation organique en aquaculture : Utilisation du lisier de porc pour l'alevinage de poissons d'étang. Thèse doctorat Ingénieur Sciences Agronomiques, Inst. Nat. Agro. Paris-Grignon, 252 p.

Lauzanne L., 1988. Les habitudes alimentaires des poissons d'eau douce africains. *In*: Lévêque C., Bruton M.N. and Ssentongo G.W. (eds.), Biologie et écologie des poissons d'eau douce africains, ORSTOM, Paris, 395–425.

Lévêque C., Paugy D. and Teugels G.G., 1992. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, Volume II, éditions ORSTOM (Paris) & MRAC (Tervuren), collection Faune tropicale XXVIII, 385–902.

Loiselle P.V., 1972. Preliminary survey of inshore habitats in the Volta Lake – A report prepared for the Volta Lake Research project, Rome, FAO, FAO/FI/DP/ CHA/67/510/2, 122 p.

Martinez-Cordova L.R., 1999. Cultivo de Camarones Peneidos, AGT Editor, Mexico, DF, 189 p.

Medeiros E.S.F. and Arthington A.H., 2008. Diet variation in food intake and diet composition of three native fish species in floodplain lagoons of the Macintyre River. *Australia Journal of Fish Biology*, *73*, 1024–1032.

Mkumbo O.C. and Ligtvoet W., 1992. Changes in the diet of Nile perch, *Lates niloticus* (L), in the Mwanza Gulf, Lake Victoria. *Hydrobiologia*, *232*, 79–83.

Moore J.W. and Moore I.A., 1976. The basis of food selection in flounders, *Platichthys flesus* (Linnaeu) in Severn Estuary. *J. Fish Biol.*, *9*, 139–156.

Ogutu-Ohwayo R., 1990. The decline of the native fishes of lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, *Lates niloticus*, and the Nile tilapia, *Oreochromis niloticus*. *Env. Biol. Fish.*, *27*, 81–96.

Ogutu-Ohwayo R., 1993. The effects of predation by Nile perch, *Lates niloticus*, on the fish of Lake Nabugabo, with suggestions for conservation of endangered endemic cichlids. *Conserv. Biol.*, *3*, 701–711.

Ogutu-Ohwayo R., 2004. Management of the Nile perch, *Lates niloticus* fishery in Lake Victoria in light of the changes in its life history characteristics. *Afr. J. Ecol.*, *42*, 306–314.

Ouéda A., Guenda W., Ouattara A., Gourene G., Hugueny B. and Kabre G.B., 2008. Seasonal diet shift of the most important fish species in a Sahelo-Soudanian reservoir (Burkina Faso). *J. of Fisheries and Aquatic Science*, *3*, 4, 240–251.

Park Y.S., Chang J., Lek S., Cao W. and Brosse S., 2003. Conservation strategies for endemic fish threatened by the three Gorges Dam. *Conserv. Biol.*, *17*, 1748–1758.

Prejs A. and Prejs K., 1987. Feeding of tropical freshwater fishes: Seasonality in resource availability and resource use. *Oecologia*, *71*, 3, 397–404.

Pusey B.J. and Bradshaw S.D., 1996. Diet and dietary overlap in fishes of temporary waters of Southwestern Australia. *Ecol. Freshwater Fish*., *5*, 4, 183–194.

Rajasilta M. and Vuorinen I., 1983. A field study of prey selection in planktivorous fish larvae. *Oecologia*, *59*, 65–68.

Rey J., 1986. Contribution à l'étude du zooplancton d'altitude et de la taxonomie des cladocères. Thèse doctorat 3e Cycle en Hydrobiologie, Université Paul Sabatier de Toulouses (Sciences), 443 p.

Ruttner A.K., 1974. Plankton Rotifers: Biology and Taxonomy in Die Binnengewässer, Vol. XXVI/1 supplement, Stuttgart, 146 p.

Sachs L., 1997. Angewandte Statistik, 8th edition, Springer, Berlin.

Schofield P.J. and Chapman L.J., 1999. Interactions between Nile perch, *Lates niloticus* and other fishes in Lake Nabugabo, Uganda. *Environ. Biol. Fish*, *55*, 343–358.

Sokal R.R. and Rohlf F.J., 1995. Biometry, 3rd edition, Freeman, New York.

Stergiou K.I. and Fourtouni H., 1991. Food habits, ontogenetic diet shift and selectivity in *Zeus faber* (Linnaeus, 1758). *J. Fish Biol.*, *39*, 589–603.

Tonney J.P. and Gibson R.J., 1989. Feeding strategies of brook trout (*Salvelinus fontinalis*) and juvenile Atlantic salmon (*Salmo salar*) in a Newfoundland river. *Can. Fld. Nat.*, *103*, 48–56.