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Predation Efficiency of Nile Catfish, *Clarias gariepinus* (Burchell, 1822) on Fry Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758): Effect of Prey Density, Predator Size, Feed Supplementation and Submerged Vegetation

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Abstract

The overpopulation of tilapia in confined ponds is an obvious problem, and causes stunted growth due to the shortage of natural food, particularly in semi-intensive culture. However, the control of tilapias population by predator culture has been practiced worldwide. The factors affecting predation efficiency of Nile catfish, *Clarias gariepinus* (B.) for controlling the overpopulation of Nile tilapia, *Oreochromis niloticus* (L.) were studied in four indoor experiments. Nile catfish with different sizes was stocked with tilapia fry (2-3 g) at the ratios of 1:10 or 1:15 (catfish : tilapia) without feeding. In another trial, Nile catfish : tilapia (1:15 ratio) with different sizes was frequently fed to satiation with fish diet (25% crude protein). The number of eaten fry was counted after 6, 24, 48 and 72 hours. The predation rate of Nile catfish at different predator sizes increased at the ratio of 1:15 more than 1:10 (catfish : tilapia) ratio. Predation rate of large Nile catfish was greater than small ones. Artificial feeding reduced the predation rate of Nile catfish at different predator sizes, while it increased with increasing predator size and tilapia stocking. In the fourth experiment, the leafless stems of phragmites plants (0.7 m long and 0.5 cm diameter) were used in this study at densities of 0, 5, 10, 20, 30 and 50 stems/m^2. The aquarium was stocked with 15 fry (2.2 g) and 1 catfish (400 g). The number of eaten fry was counted closely for 6, 24, 48 and 72 hours. The fry used the submerged macrophytes as a refuge to protect themselves from predator attack. It was concluded that predation rate of Nile catfish is dependent on predator size, prey stocking density, supplemental feeding and period of stocking. Moreover, the presence of submerged vegetation at moderate density (20-30 stem/m^2) may reduce the number of eaten fry.

Key Words: Nile catfish, *Clarias gariepinus*, predator, Nile tilapia, *Oreochromis niloticus*, prey, stocking ratio, artificial feeding, macrophytes.

Introduction

The aquaculture of species at lower trophic levels, such as tilapia, presents the greatest potential for production efficiency (Welcomme, 1996). However, overpopulation of tilapia in confined ponds causes stunted growth due to the shortage of natural food, particularly in semi-intensive culture. Various methods of population control have been applied, such as culture in cages, culture with predators, intermittent harvesting, hybridization, induction of sterility, and production of super-male fish (Mair and Little, 1991). However, population control of tilapias by culture with predators has been practiced worldwide. Various predatory fish species have been used with varying success in combination with different tilapia species depending on their availability. However, the difficulty in breeding or obtaining predators of the correct size often resulted in limited application of this population control method (Balarin and Hatton, 1979; Penman and McAndrew, 2000).

The proper use of predatory fish is considered as a safe biological method for covering tilapia overpopulation in ponds without affecting the big size prey. In this respect, Fortes (1980) used tarpon (*Megalops cyprinoides*) as a predator to control the population of Java tilapia (*Tilapia mossambica*) fingerlings in brackish water ponds. Similarly, McGinty (1983) used peacock bass (*Cichla ocellaris*) as a predator for controlling *Tilapia nilotica* in fertilized ponds. Fischer and Grant (1994) used tucunare (*Cichla monoculus*) as a native predator for controlling the overcrowding of *Oreochromis niloticus*. El Gamal (1992) and El Gamal *et al*. (1998) used Nile perch (*Lates niloticus*) and African catfish (*Clarias gariepinus*) for controlling Nile tilapia recruitment. Yi *et al*. (2004) used snakehead (*Channa striata*) as a predator in polyculture with Nile tilapia to control its recruitment. Wysujack and Mehner (2005) reported that European catfish (*Silurus glanis*) was stocked in a lake for manipulation purposes to reduce unwanted roach and bream population.

Swingle (1960) recommended the use of local predatory species for this purpose. Nile catfish, *Clarias gariepinus* (*C. lazera*) is one of the most abundant and widely distributed fish in the River Nile, its tributaries and lakes (Boulenger, 1907). Otherwise, Nile catfish is the principal clarid catfish in Africa (Teugels, 1984), where it is widely distributed throughout Africa and has long been considered as one of the most suitable species for culture in Africa

(El Bolok and Koura, 1960; DeKimpe and Micha, 1974). It is considered as an excellent pond culture fish in many countries and as the third important commercial fish in Egypt after tilapia and bagrids (Khallaf and Gaber, 1991). Moreover, *Clarias* species are widely cultivated under various systems (Huisman and Richter, 1987; Haylor, 1989). On the other hand, Nile catfish plays an important role among Nilotic species in the trophic chain where tilapias were the most preferred food item especially the young ones followed by insects, crustaceans and mollusks, respectively (Adebisi, 1981; Babiker, 1984; Khallaf and Gaber, 1991).

Huet (1970) pointed out the varying degrees of success upon using predators for the control of tilapia overpopulation. However, different ecological situations should be considered in order to select the appropriate predator for a particular situation. Therefore, this study was carried out to evaluate the impact of Nile catfish, *C. gariepinus* (B.) with different sizes on fry Nile tilapia, *O. niloticus* (L.) and to justify the prey-predator interaction in indoor experiments to be helpful when outdoor experiment will be carried out.

Materials and Methods

Different sizes of Nile catfish, *Clarias gariepinus* (35, 75, 180, 275, 400 and 650 g) were collected from fishponds located at Central Laboratory for Aquaculture Research (CLAR), Abbassa, Abo-Hammad, Sharqia, Egypt. Fry Nile tilapia, *Oreochromis niloticus* was obtained from the Abbassa hatchery at CLAR. Nile tilapia was graded for similar sizes (2-3 g) and acclimated for 15 days to laboratory conditions. Fish was disinfected by using 5 % potassium permanganate.

Total weight, total length and mouth gape of catfish were measured. Mouth gape was measured as the maximum vertical opening between the anterior ends of the upper and lower jaws as described by El Gamal *et al*. (1998). Relationships between total weight and mouth gape for Nile catfish were determined.

The first experiment was conducted to evaluate the effect of tilapia stocking density on the predation efficiency of Nile catfish. Tilapia fry were distributed randomly at a rate of 10 or 15 fish per 45-L aquarium (30 x 40 x 50 cm). Air was supplied from air-pump via air-stones. At each aquarium, one Nile catfish of each size was stocked with tilapia fry to obtain prey: predator ratios of 10:1 or 15:1. Fish were kept without feeding. The number of eaten fry was counted after 6, 24, 48 and 72 hours. Settled fish wastes were siphoned daily with half of the water volume, which was replaced by well-aerated tap water from the storage tank. Water temperature was about 25±1 ^{o}C.

In another experiment, one Nile catfish of each size was stocked with tilapia in each aquarium at the ratio of 1:15 as described previously in the first experiment. Fish were frequently fed to satiation with diet containing 25% crude protein (Atmeda factory, Egypt). Control groups were kept without supplemental feed. The number of eaten tilapia fry was counted after 6, 24, 48 and 72 hours.

The fourth experiment was conducted in the same glass aquarium (as in the first experiment) to evaluate the effect of submerged plant as a refuge on the number of eaten fry by catfish. The leafless stems of phragmites plants (0.7 m long and 0.5 cm diameter) were used in this study as described by Manatunge *et al*. (2000) and Abdel-Tawwab (2005). These bars were attached to a wire at the top and the bottom, extended to the bottom of the aquarium at five plant densities of 0, 5, 10, 20, 30 and 50 stems/m^2. The aquarium was stocked with 15 fry (2.2 g) and 1 catfish (400 g). The number of eaten fry was counted closely for 6, 24, 48 and 72 hours.

The experiments were conducted in complete randomized design and each experiment was three replicated. The obtained data were subjected to two-way ANOVA, and the differences between means were done at the 5% probability level using Tukey *post-hoc* test. Pearson correlation was also done. The software SPSS, version 10 (SPSS, Richmond, USA) was used as described by Dytham (1999).

Results

The relationship between the weight and the mouth gape of Nile catfish is shown in Figure 1. The obtained result reveals that the increase in mouth gape of Nile catfish is positively correlated with its weight where r^2 =0.8677; $P<0.05$ and the formula describing the relationship is: $Y = 8.5696 \text{ Ln } W - 10.825$, where Y = mouth gape (cm) and W = weight (g).

The impact of Nile catfish as a predator on Nile tilapia, which is one of the commonly used fish in fish farming was studied. Figure 2 reveals that the number of eaten tilapia fry increased significantly by time where the maximum prey number was recorded at 72-hour rearing period ($P<0.05$). Moreover, the predation efficiency of Nile catfish on tilapia fry increased significantly with the increase of predator size at low and high co-existence stocking ratios (r^2 = 0.6721 and = 0.6253, respectively; $P<0.05$). The predation pressure increased significantly at the ratio of 1:15 more than that at the ratio of 1:10 ($P<0.05$) in big catfish (275, 400 and 650 g) at all rearing periods, while it was only higher at 48- and 72-hour rearing periods with small catfish (35, 75 and 180 g). Also, Figure 2 shows that the catfish of small sizes (35, 75 and 180 g) did grazing of tilapia after 24 hours, while, in case of bigger ones, (275, 400 and 650 g) grazing was done after few hours only.

Concerning the addition of artificial feed to both fish, Figure 3 indicates that artificial feeding reduced the predatory rate of all catfish weights (r^2= 0.5395) at 48 and 72 hour rearing periods ($P<0.05$). The response of different catfish sizes was variable. The

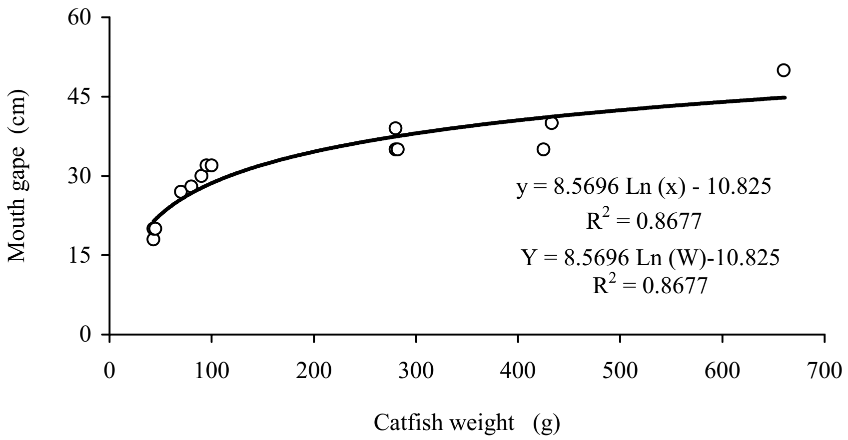

Figure 1. The relationship between total weight and mouth gape of Nile catfish (*C. gariepinus*) in Abbassa fishponds.

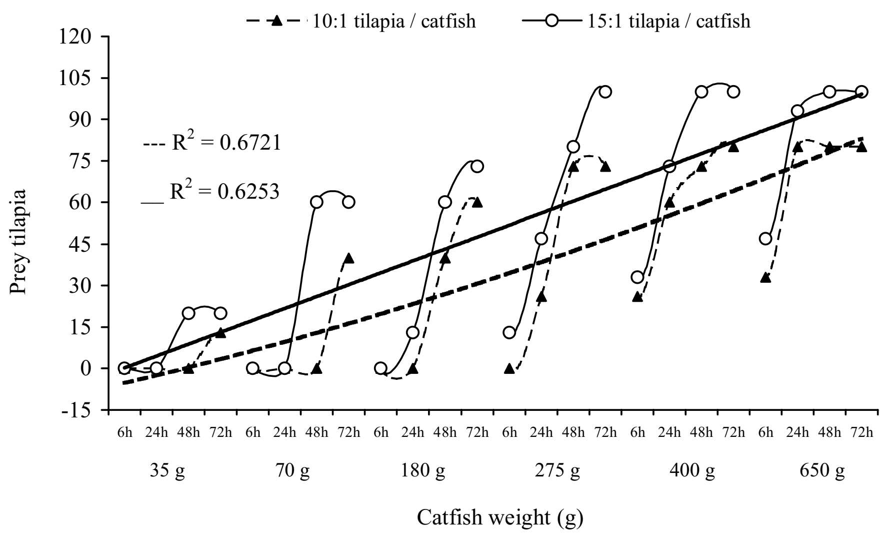

Figure 2. The impact of different sizes of Nile catfish on fry Nile tilapia at stocking ratio of 1:10 or 1:15 tilapia/catfish without artificial feeding after different times.

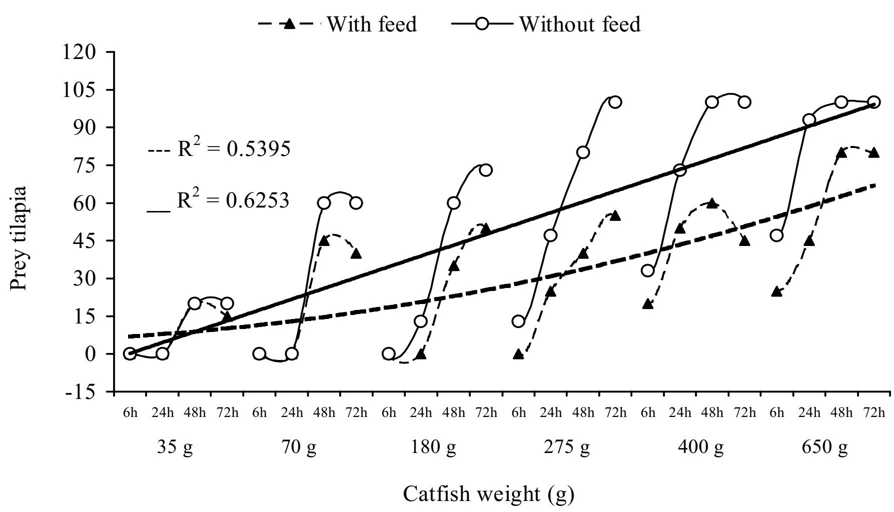

Figure 3. The impact of different sizes of Nile catfish on fry Nile tilapia at a stocking ratio of 1:15 tilapia/catfish with or without artificial feeding after different times.

lowest predatory rate was recorded at the size of 35 g, meanwhile the maximum one was recorded at the size of 400 g at 48 hour rearing period.

Figure 4 shows the effect of submerged plant on the predatory rate in glass aquaria stocked with 15:1 fry/catfish. The obtained results evoke that the number of eaten fry reduced significantly with increasing vegetation density ($P<0.05$), and the optimum vegetation density was 20-30 stem/m^2.

Discussion

The interaction between piscivorous fish as predators and their prey is mainly related to morphological constrains in the feeding process because of the limited gape size of the predator (Hambright *et al*., 1991; Nilsson and Brönmark, 2000; Wysujack and Mehner, 2005), or depends on the relative speed of predator to prey species (Christensen, 1996). Therefore, predation by piscivores may affect both density and size structure of their prey populations (Rice *et al*., 1993; Claessen *et al*., 2002).

The impact of Nile catfish as a predator on Nile tilapia*,* which is one of the commonly used fish in fish farming was herein studied. It was noticed that Nile catfish did grazing at small size (35 g). This result is in concomitant with El Gamal *et al*. (1998) who stated that African catfish with size of 13 g were able to predate as larger sizes did when they found a prey size they could handle. In general, the ratio of predator length to prey length is a good predictor of predation success (Hambright, 1991; Lundvall *et al*., 1999). In numerous studies, lengths of predator and prey were positively correlated (Mittelbach and Persson, 1998; Wysujack *et al*., 2002). Furthermore, the predator size can cause substantial differences in relative survival of different prey sizes (Rice *et al*., 1993).

The obtained results also evoked that the predatory rate of Nile catfish increased when its size increased ($P<0.05$) and tilapia density increased ($P<0.05$). These results are logic due to the increase in mouth gape of Nile catfish, which is positively correlated with its weight. However, the activity of catfish for tilapia capture, when it has big size and the number of stocked tilapia is high, increased the possibility of its capture and grazing in a certain area and *visa versa*. So, the range of prey and predator weights should thus be considered. Bruton (1979) and El Gamal (1998) indicated that the predatory rate of African catfish (*C. gariepinus*) is varied as the predator size, the prey density and/or accessibility varied. Also, Fortes (1980) studied the ratios of tarpon (*Megalops cyprinoides*) and Java tilapia (*Tilapia mossambica*) of 0:1, 1:0, 1:5, 1:10 and 1:20 (tarpon : tilapia) to establish the most effective ratio and determine the size of tilapia that tarpon could swallow. He found out that the ratio of 1 : 10 was the most desirable ratio among the tested ratios. Similarly, McGinty (1983) used peacock bass (*Cichla ocellaris*) as a predator for controlling *Tilapia nilotica* in fertilized ponds with different stocking densities (125, 250 or 375 peacock bass per hectare). He found out that decreasing predation pressure increased tilapia production as a result of increased recruitment and bass grew fastest when small tilapia recruits were abundant as prey. Fischer and Grant (1994) suggested that stocking 10 tucunare (*Cichla monoculus*) weighing either 2 g or 10 g yields the highest total net revenue at the early harvest date, while stocking 20 tucunare weighing either 2 g or 10 g yields only slightly less total net revenue. Mittelbach and Persson (1998) suggested that most variation found in the

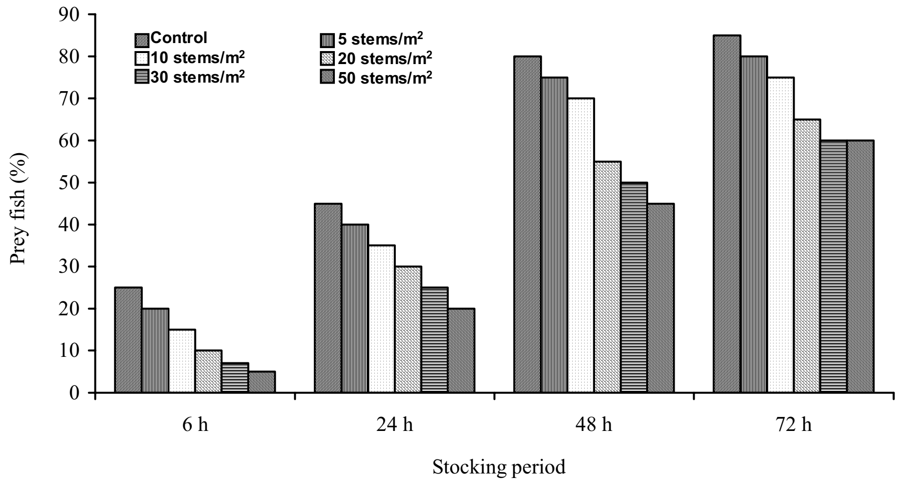

Figure 4. The effect of vegetation density on the number of preyed fish at a stocking ratio of 15 fry:1 catfish (400 g) and fed with 25% CP diet.

sizes of prey eaten by piscivores is because of differences in piscivores body size. One may, therefore, conclude that, in the presence of large predators, the predation on large prey fish will be increased. It should also be noticed that predators often take prey fish far smaller than predicted from mouth gape data (Christensen, 1996; Nilsson and Brönmark, 2000) although Nile catfish were gape limited in their feeding. In this regard, Wysujack and Mehner (2005) found out that European catfish of 150 cm length will probably feed upon only 65% of all available bream length classes.

The supplemental feeding reduced the predatory rate of catfish at all sizes. Although, a high number of tilapia fry was available, based on catfish mouth gape, they were not totally preyed. This may be due to nutritional satisfaction or activity pattern. However, both fish consumed artificial feed, and the activity of prey tilapia to escape was enhanced, meanwhile some nutritional requirement of catfish was satisfied. Therefore, the predation outcome is determined by size-dependant capture and escape abilities of catfish and tilapia, respectively.

The positive effect of vegetation density on the number of preyed fry of Nile tilapia herein may be due to either changes in the swimming speed, the decreased foraging rate due to the physical low vision, or both. On the other hand, fry might use the submerged vegetation as a refuge to protect themselves from predator attacking. In this respect, Manatunge *et al*. (2000) found out that the swimming speed and the foraging behavior of *Pseudorasbora parava* (Cyprinidae) were inversely affected by increasing stem density due to visual impairment resulting from stem presence. They also reported that the presence of macrophytes in an environment may lead to physical concealing or shielding of the frontal view and the obstruction to fish movement by the stems. These factors restrict the effective visual volume of the fish. In addition, the presence of vegetation in the environment tends to increase fish search time and pursuit times (Crowder and Cooper 1982; Anderson 1984; Cooks and Streams 1984).

The ecological problem due to vegetation presence is the decrease in light penetration. However, the low light intensity might be insufficient for fish growth regulation. In this concern, Lagler *et al*. (1977) reported that light is an ecological factor of importance in fish life, and its direct effects are through vision but there are many indirect ones as well. Especially, it has a timing role in reproduction and influence on the rate and the pattern of growth.

The natural vegetation habitat could be more complex than it was simulated herein because I did not simulate the type of plant community structure that would be found in a natural pond enclosure, which would include leafed stems (submergent) in addition to emergent plants, which may have leafless stems. These factors may limit the actual interpretation of the obtained results relative to pond environment.

Field experiments will further be done. Particularly, the prey-predator relationships in fishpond are affected by numerous factors such as fish stocking, size, food and temperature in eutrophic fishponds. Top-down control (biomanipulation) by stocking of piscivores was of limited success because of resulting co-existence of Nile catfish and tilapia above the critical size, which still contributed by their feeding mode. Moreover, in pond culture, catfish were observed consuming artificial feed, which may have softened their predatory pressure. On the other hand, the cannibalistic behavior of tilapia fingerlings could not be ignored in such systems that include different sizes of fry and fingerlings.

References

Abdel-Tawwab, M. 2005. The effect of artificial vegetation density on growth and growth related parameters of Nile tilapia, *Oreochromis niloticus* (L.) fry. Turkish Journal of Fisheries and Aquatic Sciences, 5: 63-68.

Adebisi, A. A. 1981. Analysis of the stomach contents of the piscivorous fishes of the upper Ogum River in Nigeria. Hydrobiologia, 79(2): 167-178.

Anderson, O. 1984. Optimal foraging by largemouth bass in structured environments. Ecology, 65: 851-861.

Babiker, M. 1984. Aspects of the biology of the catfish *C. lazera* related to economic cultivation. Hydrobiologia, 110: 295-304.

Balarin, J.D. and Hatton, J.P. 1979. Tilapia: A Guide to Their Biology and Culture in Africa. Unit of Aquatic Pathology, University of Stirling, Scotland.

Boulenger, G.A. 1907. The Fishes of the Nile. Published by Hugh Ress Ltd., London.

Bruton, M.N. 1979. Food and feeding behaviour of *Clarias gariepinus* (Pisces: Clariidae) in lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids. Transaction of Zoological Society, 25(1): 47-114.

Christensen, B. 1996. Predator foraging capabilities and prey antipredator behaviours: pre- versus postcapture constraints on size-dependent predator-prey interactions. Oikos, 76: 368-380.

Claessen, D., Van Oss, C., de Roos, A.M. and Persson, L. 2002. The impact of size-dependant predation on population dynamics and individual life history. Ecology, 83: 1660-1675.

Cooks, W.L. and Streams, F.A. 1984. Fish predation on Notonecta (Hemipetra): relationship between prey risk and habitat utilization. Oecologia, 64: 177-183.

Crowder, L.B. and Cooper, W.E. 1982. Habitat structural complexity and the interaction between bluegills and their prey. Ecology, 63: 1802-1813.

DeKimpe, P. and Micha, J.C. 1974. First guidelines for the culture of *Clarias lazera* in Central Africa. Aquaculture, 4: 227-248.

Dytham, C. 1999. Choosing and Using Statistics: A Biologist's guide. Blackwell Science Ltd., London, UK.

El Bolok, A.R. and Koura, R.C. 1960. Observations on age, growth and feeding habits of *Clarias lazera* in Barrage experimental ponds. Notes Mem. Hydrobiologia Dept., Ministry of Agriculture, UAR, No. 56, 17 pp.

El Gamal, A.A. 1992. Predation by Nile perch *Lates* *niloticus* L. on *Oreochromis niloticus* (L.), *Cyprinus carpio* (L.), *Mugil* sp. and its role in controlling tilapia recruitment in Egypt. Journal of Fish Biology, 40: 351-358.

El Gamal, A.A., Abdel-Halim, A.M.M., Abdel-Razek, E. and Soliman, A. 1998. Biological studies on Nile perch *Lates niloticus* (L.) and African catfish *Clarias gariepinus* (T.) in reference to their food habits and predation patterns in culture ponds. Egyptian Journal of Agricultural Research, 76(1): 335-349.

Fischer, G. W. and Grant, W. E. 1994. Use of a native predator to control overcrowding in warm-water polyculture ponds: Simulation of a tucunare (*Cichla monoculus*) - tilapia (*Oreochromis niloticus*) system. Ecological Modeling, 72(3): 205-227.

Fortes, R. D. 1980. Tarpon as predator to control Java tilapia young in brackishwater ponds. Fisheries Research Journal of the Philippines, 5(2): 22-35.

Hambright, K.D. 1991. Experimental analysis of prey selection by largemouth bass: the role of predator mouth width and prey body depth. Transaction of the American Fisheries Society, 120: 501-508.

Hambright, K.D., Drenner, R.W., McComas, S.R. and Hairston, N.G. 1991. Gape-limited piscivores, planktivore size refuges, and the trophic cascade hypothesis. Archiv fur Hydrobiologie, 121: 389-404.

Haylor, G. S. 1989. The case for the African catfish *Clarias gariepinus* (Burchell, 1822), Clariidaw: comparison of relative merits of Tilapine fishes especially *Oreochromis niloticus* (L.) and *C. gariepinus* of African culture. Aquaculture and Fisheries Management, 20: 279-285.

Huet, M. 1970. Breeding and Cultivation of Fish. Fishing New Books Ltd., London.

Huisman, E. A. and Richter, C. J. 1987. Reproduction, growth, health control and aquaculture potential of the African catfish *Clarias gariepinus* (Burchell, 1822). Aquaculture, 63: 1-14.

Khallaf, E.A. and Gaber, N. 1991. Analyses of stomach contents and intraspecific interaction over diet of *Clarias lazera* (Cuv. & Val.) in Bahr-Shebeen canal. Bulletin of Faculty of Science Zagazig University, 13(2): 481-499.

Lagler, K.F., Bardach, J.E., Miller, R.R. and MeyPassino, D.R. 1977. Ichthyology. The 2nd edition, John Wiley and Sons, New York.

Lundvall, D., Svanbäck, R., Persson, L. and Byström, P. 1999. Size-dependent predation in piscivores: interactions between predator foraging and prey avoidance abilities. Canadian Journal of Fisheries and Aquatic Sciences, 56: 1285-1292.

Mair, G.C. and Little, D.C. 1991. Population control in farmed tilapias. NAGA, the ICLARM Quarterly, 4(2): 8-13.

Manatunge, J., Asaeda, T. and Priyadarshana, T. 2000. The influence of structural complexity on fish-zooplankton interactions: A study using artificial submerged macrophytes. Environmental and Biology of Fishes, 58: 425-438.

McGinty, A. S. 1983. Population dynamics of peacock bass, *Cichla ocellaris* and *Tilapia nilotica* in fertilized ponds. In: L. Fishelson and Z. Yaron (Eds.), Proceeding International Symposium on Tilapia Aquaculture. Tel Aviv University, Nazareth, Israel: 86-94.

Mittelbach, G.G. and Persson, L. 1998. The ontogeny of piscivory and its ecological consequences. Canadian Journal of Fisheries and Aquatic Sciences, 55: 1454-1465.

Nilsson, P.A. and Brönmark, C. 2000. Prey vulnerability to a gape-size limited predator: behavioural and morphological impacts on northern pike piscivory. Oikos, 88: 539-546.

Penman, D.J. and McAndrew, B.J. 2000. Genetics for the management and improvement of cultured tilapias. In: M.C.M. Beveridge and B.J. McAndrew (Eds.), Tilapia: Biology and Exploitation. Kluwer Academic Publishers, the Netherlands: 27-38.

Rice, J.A., Crowder, L.B. and Rose, K.A. 1993. Interactions between size-structured predator and prey populations: experimental test and model comparison. Transaction of the American Fisheries Society, 122: 481-491.

Swingle, H. S. 1960. Comparative evaluation of two tilapias as pond fishes in Alabama. Transaction of the American Fisheries Society, 8: 142-148.

Teugels, G.G. 1984. The nomenclature of African *Clarias* species used in Aquaculture. Aquaculture, 38: 373-374.

Welcomme, R.L. 1996. Aquaculture and world aquatic resources. In: D.J. Baird, M.C.M. Beveridge, L.A. Kelly and J.F. Muir (Eds.), Aquaculture and Water Resources Management. Blackwell Science Ltd., London: 179-213.

Wysujack, K. and Mehner, T. 2005. Can feeding of European catfish prevent cyprinids from reaching a size refuge? Ecology of Freshwater Fish, 14: 87-95.

Wysujack, K., Kasprzak, P., Laude, U. and Mehner, T. 2002. Management of a pikeperch stock in a long-term biomanipulated stratified lake: efficient predation vs. low recruitment. Hydrobiologia, 479: 169-180.

Yi, Y., Diana, J.S., Shrestha, M.K. and Lin, C.K. 2004. Culture of mixed-sex Nile tilapia with predatory snakehead. In: R. Bolivar, G. Mair and K. Fitzsimmons (Eds.), The 6th International Symposium of Tilapia in Aquaculture, 14-16 Sep. 2004, Manila, Philippines: 664-557.