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SURVIVAL AND GROWTH RATES OF EARLY STAGES OF SOME FISH SPECIES REARED WITH THE FRESHWATER CRAYFISH, *PROCAMBARUS CLARKII* (GIRARD, 1852)

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Key words: *Procambarus clarkii* , freshwater fish , mixed culture, growth , survival rates.

ABSTRACT

A Group of the exotic crayfish, *Procambarus clarkii* (total length ranging from 4 to 6.1 cm) was held with the early stages of fry of common carp, *Cyprinus carpio* Linnaeus, 1758 ; silver carp, *Hypophthalmichthys molitrix* (Valenciennes,1844) ; Nile tilapia, *Oreochromis niloticus* (Linnaeus,1757) ; and *Sartherodon galilaeus* (Artedi,1757), with initial average length ranging from 2 to 2.5 cm and fingerlings with initial average length ranging from 4.1 to 5.8 cm . Each species were held separetely with the crayfish , aiming to find out its effect on both survival and growth rates of the above fin fish in polyculture.

The results indicated that the survival rates ranged from 74.4 to 88.9% compared with a range of 76.6 to 94.65% in control experiments for the early fry stages of the four different fish species. For the fingerlings the range was 71.1 to 93.3% compared with 76.65 to 93.35 % in control experiments .

There were no significant differences in the survival rate of the four fish species cultured in combination with the crayfish and the fish kept alone (control).

When rearing *O. niloticus* (2.3 g in weight and 4 cm in length) with young crayfish (1.76 g in weight and 4.39 cm in total length) for three months, the results showed that the final weight was significantly different ($P < 0.01$) for fish reared alone, while no significant differences were observed in weight gain and specific growth rate. There was, however, a significant difference ($P< 0.001$) in the final weight for crayfish reared in combination with tilapia, while there were no significant differences in weight gain or specific growth rate. It seems that the presence of crayfish in a mixed culture

with some fish species did not adversely influence the survival and growth rates of early stages of either tilapia spp. or carp spp.

INTRODUCTION

The freshwater crayfish, Procambarus clarkii was accidentally introduced to the Egyptian Nile water during the early eighties of the last century (Ibrahim *et al.* 1995). It has spread in most of the irrigation canals and branches of the Nile. The crayfish does not require certain quality of water for aquaculture (Dupree & Huner, 1984; Huner and Barr, 1984) and is well suited for polyculture with fish (Huner, 1986).

Polyculture combinations involves the culture of several compatible fish species with different food habits, but inclusion of mollusces (Swingle, 1968)) and crustaceans (Tuten, 1977; Green *et al.* 1978 ; Sadek, 1992, 1993; Sadek and El- Gayar, 1995; Sadek and Moreau, 1996, 1998) was practised . Species that possess different food habits will utilize more completely the available food sources in ponds .

Polyculture is practiced in different parts of the world, including Africa, Europe, India and North America and combination of polyculture includes species that feed low in the food chain (Yashouv, 1968 ; Huet, 1970 and Bardach *et al.* 1972), aiming at increase the overall production .

Culture of the freshwater crayfish *Procambarus clarkii* has attracted considerable attention in warm temperate regions like other crustaceans such as shrimp. This species is reared in monoculture, mixed or polyculture systems with fish as indicated by Green *et al.* (1978) and Huner *et al.* (1983) who studied the interaction of the freshwater prawn, catfish and crayfish in earthen ponds.

The cost of cultivation of the crayfish is low compared to that of other crustaceans, such as prawn, shrimp and crab. Though, it was believed that *Procambarus clarkii* damage fishery and agricultural resources, especially pond fishes, Shu and Yiuzo (1989) showed that crayfish do not reduce the yield of pond fish.

The present study was initiated aiming to find out the effect of crayfish on the survival rates of the fry and fingerlings of some freshwater fish , when reared together, and to study the effect of mixed culture on the growth rate of both the crayfish, *Procambarus clarkii* and *Oreochromis niloticus* when reared together .

MATERIALS AND METHODS

- **Site of work and design of experiments**

The experimental work was carried out at Invertebrate laboratory, Fish Research Station, National Institute of Oceanography and Fisheries in El-Qanater El-Khayriya.

In the first series of experiments forty glass aquaria (60×40 ×30 cm), each was filled with 30L dechlorinated tap water. The water in each aquarium was continuously aerated by means of an electric compressor. Juvenile crayfish, *Procambarus clarkii* were held with the fry and fingerlings of common carp, *Cyprinus Carpio*; silver carp, *Hypophthalmichthys molitrix*; and two species of tilapia, namely: *Oreochromis niloticus* and *Sarotherodon galilaeus*. A pair of crayfish was stocked with 30 fry in each aquarium, and another pair of crayfish was stocked with 15 fingerlings of each species in each aquarium in triplicate . Thirty fish fry and 15 fingerlings of each species were stocked alone in duplicate in control trials (without crayfish). Crayfish used have a total length ranging from 4 to 6.1 cm, while the fry of the different fish species have average initial lengths ranging from 2 to 2.5 cm , and for fingerlings the average initial length ranged from 4.1 to 5.8 cm for the different species. The experiments were conducted for three weeks during July 2000 , at an average water temperature 23.8 C° ± 0.816 .

In the second series of experiments, six glass aquaria of the same size (60× 40 ×30 cm) were used and stocked as follows : two glass aquaria were stocked with crayfish only (average initial weight 0.889 g and 3.7 cm in total length), 30 individuals / aquarium . Two aquaria were stocked with Nile tilapia, *O. niloticus* (average initial weight 3.1 g and 5.6 cm. in length) 30 fish / aquarium, and the last two aquaria were stocked by a combination of the two species, 15 individuals / aquarium for each species (crayfish with an initial mean weight 1.76 g and total length 4.39 cm , Nile tilapia has initial mean weight 2.3 g and initial mean length 4 cm) . The experiments were conducted for three months (August, September and October, 2000), at an average water temperature 23.8 C° ± 0.186 .

- **Water quality**

During the experiment, the oxygen concentration ranged from 7.2 to 9.5 mg / l with an average 8.3 ± 0.901 and pH values ranged from 7 to 7.8 with an average 7.4 ± 0.343 (Table 1) , being within the suitable limits for fish culture .

- **Food used**

Artificial feed used in the two series of experiments was made of locally available ingredients. It consisted of fish meal, yellow corn, wheat bran, soybean, cotton seed oil and vitamins, to formulate a dietcontaining 35% protein. The food was applied daily at 3% of the body weight, and the remainders of the diet and detritus were removed daily by siphoning through out the experimental period. The water was changed at least once every 2 days.

In order to test the significance of the differences between the mean values of any two sets of observation, t-test was applied according to the method of Baily (1959).

RESULTS

In the first series of experiments, when the early fry stages and fingerlings of common carp, *C. carpio*, silver carp, *H. molitrix*, tilapias *O. niloticus* and *S. galilaeus* were kept with young crayfish for three weeks , the results showed that the survival rates for common carp ranged from 83.7 to 90% with a mean of 86.8% for fry and from 86.7 to 100% with a mean of 93.3% for fingerlings . In the control group, the survival rates were 86.7 and 90% with a mean of 88.35% for fry and 86.7% and 100% with a mean of 93.35% for fingerlings (Table 2) .

For silver carp, the survival rates ranged from 70 to 80% with a mean of 74.4% for fry and from 66.7 to 73.3% with a mean of 71.1% for fingerlings, while in control, the survival rates were 73.3 and 80% with a mean of 76.65% for both fry and fingerlings.

With respect to tilapia species, the survival rates ranged from 76.7 to 80% with a mean of 78.9% for fry of *O. niloticus* and from 80 to 86.7% with a mean of 82.2% for fingerlings, while in the control, group, the survival rates were 83 and 86.7% with a mean of 84.85% for fry and 86.7% and 93.3% with a mean of 90% for fingerlings of the same species.

For *S. galilaeus*, the survival rates of fry ranged from 86.7 to 90% with a mean of 88.9% ,and for fingerlings it ranged from 80 to 86.7% with a mean 84.5% . In the control group, the survival rates for the fry were 93.3 and 96%, with a mean of 94.65%, and for fingerlings it was 86.7 and 93.3% with a mean of 90% . The results indicate that there were no significant differences in the survival rates for both early fry stages and fingerlings of different species of fish reared alone or with crayfish .

The final mean of body length of common carp fry reared with crayfish ranged from 2.5 to 2.9 cm and from 5 to 5.3 cm for fingerlings, while the mean body lengths in control experiment were 2.6 and 2.9 cm for fry and 5 and 5.1 cm for fingerlings.

For silver carp, the average final body length of fry held with crayfish ranged from 3 to 3.3 cm and for fingerlings from 6.2 to 6.7 cm, while in control it was 3.3 and 3.4 cm for fry and it were 6.2 and 6.4 cm for fingerlings .

The final mean of body length for *O. niloticus* fry ranged from 2.6 to 2.8 cm and from 6.2 to 6.3 cm for fingerlings, compared with 2.7 and 2.9 cm in control group for fry and 6.5 cm for fingerlings for the same species.

For the other species of tilapia *S. galilaeus*, the final mean length ranged from 3 to 3.3 cm for fry and from 6.5 to 6.7 cm for fingerlings, compared with 3 to 3.1 cm for fry and 6.3 and 6.5 cm for fingerlings in control (where fish were kept alone without crayfish).

It is concluded that there were no significant differences between growth of fish reared alone or in combination with crayfish for the four species either early fry stages or fingerlings .

In the second series of experiments young crayfish was stocked either singly or in combination of advanced fingerlings of *O. niloticus* . The results (Table 3) indicate that tilapia stocked alone has a weight gain of 2.2 g , and a length of 1 cm, while tilapia stocked in combination with crayfish have a weight gain of 1.9 g and 1.5 cm in length . The results suggest that there were no significant differences in weight gain , specific growth rate and gain in weight / fish / day , while the final weight was significant ($P< 0.01$) for fish reared alone and represented by 5.3 g. The final weight for Nile tilapia stocked with crayfish was 4.2 g with no significant differences.

With respect to crayfish reared alone , there were no significant differences in weight gain , specific growth rate and gain in weight / individual / day. while there was a highly significant difference in final weight ($P< 0.001$) for crayfish reared in combination with tilapia, being 7.1g. The final total length was 4.8 cm for crayfish stocked alone , while it was 6.5 cm for crayfish stocked in combination with Nile tilapia .

The survival rate for Nile tilapia was 72 % in polyculture system, while it was 70 % in monoculture . For crayfish it was 75 and 69 % in both mono and polyculture respectively .

DISCUSSION

In the first series of experiments, the present results suggest that there were no significant differences between survival rates for the four fish species (common carp, silver carp and the two tilapia spp) reared with crayfish and fish kept alone without crayfish (control). These results agree with those obtained by Shu- Xinya (1995) who reported that at the Tung-Sihu Fish Farm, the survival rate of fry (grass carp, silver carp and common carp) in ponds with crayfish is usually 70 to 80 % and there was no significant difference in survival rates at Fish Farm without crayfish . This was attributed to the behaviour of fish that usually live near the water surface and feed on plankton, while the crayfish is a benthic crustacean, consuming bottom water weeds and detritus. It is concluded from the present results that the crayfish does not compete with the early stages of fish (fry and fingerlings) for space and food. The crayfish moves slowly on the bottom of the aquarium and feeds on food which fall down and other remnants. Also the crayfish in the present study seems not to nimble as fish fry and fingerlings as it is unable to prey on healthy fish .

In contrast of these results, Huner *et al.* (1983) found that the survival rate and production values were lowest for the prawn *Macrobrachium rosenbergii* in polyculture ponds with catfish and crayfish. However, Martino and Wilson (1986) studied the interaction of tilapia (*Tilapia mossambica*) ,crayfish (*P. clarkii*) and freshwater prawn (*M. rosenbergii*) in aquaculture, and found that tilapia appeared to have no apparent negative impact on the survival or growth of the crustaceans and the three species may be cultured together in ponds without any negative behaviour interactions.

On rearing *M. rosenbergii* with *O. niloticus*, there were no significant differences between mono and polyculture treatments for the mean survival rates for both fish and prawn but a higher survival rate was observed in polyculture system (Garia-Perez *et al.*, 2000) .

The results of the present study suggest that both fry and fingerlings of the four fish species grew well with as without crayfish . Therefore , it is concluded that the crayfish do not adversely influence the survival and growth rates of the fish fry and fingerlings throughout the experimental period.

The results of the second series of experiments indicated that the growth of crayfish was higher in mixed culture system than in monoculture system. This agrees with the findings of Siddiqui *et al.*

(1996) that the total production of prawn from polyculture ponds (196 days) was almost five times as great as that of monoculture ponds. Hence, the polyculture of freshwater prawn, *M. rosenbergii* with Nile tilapia, *O. niloticus* and common carp, *C. carpio* is more productive .

Also the present results are in agreement with that obtained by Sarangi *et al.* (1998) who showed that the prawn, *M. rosenbergii* reached the weight of 50-150 g. and has higher survival rate after 224 days, when reared with carp in polyculture trials Andamans in India. They attributed this result to the low stocking density, better management of water quality in the ponds and feed .These results indicated that polyculture of *M. rosenbergii* with carps has a potential effect in ponds in island conditions.

Malecha *et al.* (1981) and Buck *et al.* (1981) reported a negative interaction between the prawn, *M. rosenbergii* and the common carp. Rouse and Stickney (1982) found recognizable but insignificant reduction in growth and yield in polyculture, in comparison with monoculture. Similarly, when rearing *M.rosenbergii* with *Tilapia aurea*, Costa-Pierce *et al.* (1987) found higher prawn growth , survival and yield in monoculture , but the differences from polyculture were not significant.

In contrast to the present results, Wang *et al.* (1998) reported that the growth rates of the Chinese shrimp, *Penaeus chinensis* in enclosures with tilapia (not in net cages), were significantly lower than those in enclosures with tilapia, held in net cages one month after stocking of tilapia indicating that the tilapia has competed with the Chinese shrimp. Also Gonzales-Corre (1988) reported that competitive index of the Nile tilapia was higher than the tiger shrimp (*Penaeus monodon*).

Garcia-Pêrez *et al.* (2000) reared *M. rosenbergii* with *Oreochromis niloticus* in a polyculture system . In comparing fish growth, there was no significant differences between monoculture and polyculture treatments for the mean survival rates, final weight and total yields, while for prawn growth, there was a significant difference ($P<0.05$) between the mean final weight, growth rate and total yield in mono and polyculture. They also showed that the increase in weight of prawn in monoculture treatment was almost twice the value as in the polyculture treatment . They attributed this to the presence of tilapia which may have efficiently consumed a major portion of the artificial feed, leaving little for the prawn. Rouse and Stickney (1982) reported competition for food between the same two

species because fish feed rapidly near the surface, allowing them to eat a great proportion of the supplemental feed than the prawn.

However, studies conducted by Sadek and Moreau (2000) in Egypt who cultured *Macrobrachium rosenbergii* and *Penaeus semisulcatus* and the red tilapia , *Oreochromis urolepis* which were added in the polyculture ponds, showed that either the freshwater or the marine shrimp growth, survival and yield were not affected by the presence of red tilapia . Cohen *et al.* (1983) found that the ecological instability of the prawn monoculture is solved by employing the strategy of introducing sanitary fish in ponds and this improved pond eco-system stability, without affecting prawn yield , survival or average weight . Wohlfarth *et al.* (1985) and Hulata *et al.* (1990). did not find any negative interaction between *M. rosenbergii* and the fish at a low prawn density polyculture.

Ahmed *et al.* (1996) reared *M. rosenbergii* with silver carp and found that fish growth was not influenced by the polyculture system. They concluded that a polyculture system with prawn will not affect carp production or growth. Tacon (1997) recorded that the polyculture system is an alternative to reducing cost because polycultured animals use the feed more efficiently.

In the present study, the difference in growth rate of both fish and crayfish in mono and mixed culture may be due to the competition between them for food in mixed culture system, so at a rate of food increase, a higher growth rate for crayfish in mixed culture is expected.

The results of this study indicate that mixed culture of crustaceans with fish is more productive and should be practiced on a large scale on Egypt.

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Table (1): Water quality of the experimental aquaria throughout the experimental period.

Items	Minimum	Maximum	Average ± SD
Water temperature °C	23	25	23.8 ± 0.816
pH	7	7.8	7.4 ± 0.343
Dissolved oxygen mg/l	7.2	9.5	8.3 ± 0.901

Table (2) : Summary of crayfish rearing trials with fry and fingerlings of different species of fishes.

Exp. No.	Species	No. of fish	Survival %	Initial average length (cm)	Final average length (cm)
	Common Carp				
	Cyprinus carpio				
	Fry with crayfish				
1		30	90.0	2.0	2.5
2		30	86.7	2.1	2.6
3		30	83.7	2..2	2.9
		Mean → 86.8			
4	Fry without crayfish	30	90.0	2.4	2.9
5	(Control)	30	86.7	2.0	2.6
		Mean → 88.35			
	Fingerling with crayfish				
6		15	93.3	4.1	5.0
7		15	86.7	4.5	5.1
8		15	100	4.3	5.3
		Mean → 93.3			
	Fingerling without crayfish				
9	Control	15	86.7	4.4	5.0
10		15	100	4.3	5.1
		Mean → 93.35			

Table (2) Continued

Exp. No.	Species	No. of fish	Survival %	Initial average lenght (cm)	Final average length (cm)
	Silver carp				
	Hypophthalmichthys molitrix				
	Fry with crayfish				
1		30	73.3	2.5	3.3
2		30	70.0	2.3	3
3		30	80.0	2.5	3.1
		Mean → 74.4			
4	Fry without crayfish	30	80.0	2.4	3.3
5	(Control)	30	73.3	2.5	3.4
		Mean → 76.65			
	Silver carp				
	Hypophthalmichthys molitrix				
6	Fingerling with crayfish	15	73.3	5.5	6.4
7		15	73.3	5.4	6.2
8		15	66.7	5.6	6.7
		Mean → 71.1			
9	Fingerling without crayfish	15	73.3	5.6	6.2
10	(Control)	15	80.0	5.7	6.4
		Mean → 76.65			

Table (2) Continued

Exp. No.	Species	No. of fish	Survival %	Initial average length (cm)	Final average length (cm)
	Tilapia species				
	1- *Oreochromis niloticus*				
	Fry with crayfish				
1		30	80.0	2.1	2.8
2		30	80.0	2.0	2.6
3		30	76.7	2.1	2.7
		Mean → 78.9			
	Fry without crayfish				
4	(Control)	30	83.0	2.3	2.9
5		30	86.7	2.2	2.7
		Mean → 84.85			
	Fingerling with crayfish				
6		15	86.7	5.4	6.2
7		15	80.0	5.5	6.3
8		15	80.0	5.2	6.2
		Mean → 82.2			
	Fingerling without crayfish				
	(Control)				
9		15	86.7	5.6	6.5
10		15	93.3	5.5	6.5
		Mean → 90.0			

Table (2) Continued

Exp. No.	Species	No. of fish	Survival %	Initial average length (cm)	Final average lenght (cm)
	2- *Sarotherodon galilaeus*				
	Fry with crayfish				
1		30	90.0	2.3	3.2
2		30	90.0	2.2	3.3
3		30	86.7	2.3	3.0
		Mean → 88.9			
	Fry without crayfish				
	(Control)				
4		30	93.3	2.3	3.1
5		30	96.0	2.1	3.0
		Mean → 94.65			
	Fingerling with crayfish				
6		15	86.7	5.7	6.5
7		15	80.0	5.8	6.7
8		15	86.7	5.6	6.5
		Mean → 84.5			
	Fingerling without crayfish				
	(Control)				
9		15	86.7	5.5	6.3
10		15	93.3	5.5	6.5
		Mean → 90.0			

Table (3) : Growth parameters for crayfish , *Procambarus clarkii* and *Oreochromis niloticus* in mono- and mixed culture

Items	Monoculture		Mixed culture	
	Crayfish	Fish	Crayfish	Fish
Initial weight (g)	0.899	3.1	1.76	2.3
Final weight (g)	3.0	5.3*	7.1**	4.2
Weight gain (g)	2.1	2.2	5.3	1.9
% weight gain	233.6	70.97	301.1	82.6.
Gain in weight / individual/day (g)	0.023	0.024	0.059	0.021
Specific growth rate in weight (SGR)	1.34	0.593	1.55	0.661
% survival	75	70	69	72
Initial length (cm)	3.7	5.6	4.39	4.0
Final length (cm)	4.8	6.6	6.48	5.5
Gain in length (cm)	1.1	1.0	2.1	1.5

▫Mean of final weight of fish in monoculture followed by (*) differs significantly at $P \leq 0.05$

▫Mean of final weight of crayfish in mixed culture followed by (**) differs significantly at $P \leq 0.01$.