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Artificial Spawning and Feeding of European Catfish, *Siluris glanis* L., in Turkey

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Abstract: This study focused on spawning and larval rearing of European catfish, *Silirus glanis* L., under hatchery conditions in Turkey. It was carried out to establish traditional production method for artificial breeding of European catfish in Turkey. The aim of this study was to introduce European catfish to aquaculture sector of Turkey. In spite of having suitable climate and water conditions in many regions, the catfish has not been farmed in Turkey. According to sexes of the brood catfish were separated as male and female in different tanks as soon as they reached to their sexual maturity when water temperature was being raised to 20°C. The Carp pituitary was injected to brook stocks at the rate of 3-4 mg kg^{-1} body weight. Eggs which were fertilized by drying method were loaded in Zuger jars. Larvae were fed with egg yolk, zooplankton, chironomid larvae and tubifex in polyester tanks during one week. A portion of post larvae were stocked in polyester tanks and they were fed with carp food (containing 35% protein), at a rate of 2.5%-livefish weight for 1 month. The other portion of post larvae was released to earthen ponds, fertilized with organic and inorganic fertilizers, for 1 month+2.5 months (totally 105 days). The larvae, in the earthen ponds, were fed with carp food (containing 35% protein), at a rate of 2.5%-livefish weight. At the end of the study, survival rates were found as 79.5% for incubation, 76.2% for prelarvae, 56.4-77.1% for post larvae. Survival rates in earthen ponds were calculated as 13.4% for 1 month period and 9.4% for summer season (2.5 months). Survival rate for fish fed with tubifex and carp feed in polyester tank was found as 73.1% during one month. The weights were 1.55±0.16 g for earthen pond culture and 3.6±0.08 g for polyester tank culture at the end of 1 month trial period. The growth and survival rates between earthen pond and polyester tank culture were significantly different ($p<0.05$). The weight was calculated as 74.2±0.26 g in the earthen pond at the end of study (after 105 days). As a result, it will be more suitable for European catfish production that is carried our in controlled tanks for 1 month to be transferred into earthen or wide ponds. It is better to say, this study fulfills a requirement for the favor of Turkish Aquaculture sector which is to bring in this fish to our sector.

Key words: Artificial spawning, European catfish, *silurus glanis*, feeding, growth

INTRODUCTION

The catfish used for commercial breeding belongs to *Ictaluridae, Claridae, Pangasidae* and *Siluridae* families, show significant diversity and wide range in the world. The European catfish, *Silurus glanis*, also known as wels catfish or sheatfish, is the largest European freshwater fish, being native to Eastern Europe and Western Asia. The European catfish inhabits the lower reaches of large rivers and muddy lakes, tends to prey on fish smaller than which could be expected for its size and mouth gape (Ada´mek *et al*., 1999; Wysujack and Mehner, 2005). Catfish is nowadays popular among European anglers and has been introduced in many European countries, including France, Italy, the Netherlands, Spain and the UK (Elvira, 2001). *Silurus glanis* is an economically valuable fish due to its very tasty flesh and it lives in all inland waters of Turkey except for Southeast Anatolia and the southern part of Eastern Anatolia (Celikkale, 1994). Catfish is also an increasingly important aquaculture resource in Central and Eastern Europe and most research has been devoted to aquaculture development (Ada´mek *et al*., 1999; Alp *et al*., 2004). The diversity in culturing methods is very large. It has been cultured with traditional methods in some South-east European Countries and in South Asia (Pillary, 1993). The European catfish has been cultured for its commercial value extending from Eastern Europe to Western Asia (Celikkale, 1994). Another purpose of

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European catfish breeding is keeping some carp species population under control. The European catfish has been used to decrease the number of carp species, undesirable in natural surroundings, in Europe. The European catfish has been farmed in geothermal waters, in cages, in open door systems and in ponds as mono culture recently (Proteau *et al*., 1996). The total aquaculture production of European catfish from 10 European countries (Austria, Bulgaria, Croatia, Germany, France, Hungary, Greece, Macedonia, Poland, Czech Republic and Romania) was around 2000 tons in 2001 (Linhart *et al*., 2002). In 2004, worldwide *Silurus asotus* production was 246857 tons (FAO Fisheries Statistics, 2004).

The European catfish has been distributed to all regions in Turkey except for the South-Eastern Anatolia Region and South of Eastern Anatolia (Celikkale, 1994; Geldiay and Balik, 1996). According to The State Statistical Institute of Turkey (SSI), the production of catfish is 1792 kg in these regions of Turkey (Anonymous, 1995). In spite of having suitable climate and water in many regions, the catfish has not been farmed in Turkey (Alpbaz and Hossucu, 1988).

The first report concerning attempts at artificial reproduction of European catfish and the results of its controlled spawning was published in the 1970s (Fijan, 1975; Horvath and Tomas, 1976; Kouril and Hamackova, 1977). Brood fish suitable for stripping are selected in May-July and kept separately in tanks divided into several compartments (Linhart and Billard, 1995) or if kept together the mouth of fish may be drilled after anesthetization to restrict injury due to mutual attack. This application has no adverse effect on sexual maturation or respiration (Horvath and Tomas, 1976). Hormonal treatments for induced spawning are practiced in European catfish and mostly based on the use of Carp Pituitary (CP). Female ovulates after one or two CP dose of 4-5 mg kg^{-1} body weight and males after a single injection of 3-5 mg kg^{-1} body weight or with 40 μg kg^{-1} of GnRHa (Kobareline-mamalian D-Ala^6 manufactured in the Czech Republic) (Fijan, 1975; Horvath and Tomas, 1976; Linhart and Billard, 1994; Kouril *et al*., 1995; Linhart *et al*., 2002). A single injection of LH-RH analogue (LHRHa) after being combined with pimozide was successful in spawning female (Epler and Bieniarz, 1989). Brzuska and Adamek (1999) and Brzuska (2001) reported that LHRHa and pimozide and Ovopel (LHRHa, D-Ala^6 manufactured in Hungary) without pimozide, successfully stimulated ovulation. The importance of sufficient volume of sperm, storage and sperm motility were reported (Linhart *et al*., 1987; Legendre *et al*., 1996). The sperm is stripped into an immobilization solution (IS) (Linhart *et al*., 1987) or obtained surgically from sacrificed males (Fijan, 1975; Krasznai *et al*., 1980). The use of immobilizing solution (137 mM NaCl, 67 mM KCl, 133 mM glycine) was compared by Linhart *et al*. (1987) with pure sperm or sperm squeezed out of the testes of killed males, increased egg fertilization rate and the number of sac fry. Contamination ova by urine during stripping should be avoided; the sperm is stored in immobilizing solution of 170-200 mM NaCl, 30 mM Tris-HCl, Ph 7 (Linhart and Billard, 1994; Linhart *et al*., 2004) and stored for 48-72 h at 4°C. Ova and sperm mixed in a solution made of 17 mM NaCl, 5mM Tris-HCl, pH 7, optimum temperature is between 21-23°C for fertilization (Linhart *et al*., 2004). Hovart (1977) used an activation solution (AS) of 0.3 % NaCl for fertilization. The optimum volume is 2 mL sperm+immobilizing solution (usually of light-whitish color) with a minimum concentration of $0.08.10^9$ mL^{-1} spermatozoa per 100 g of ova (160 ova per 1 g) and 50 mL of activating solution (Linhart *et al*., 2002).

After 5 min, fertilized eggs are incubated in the Weiss jars or in a net in tank. The eggs' stickiness is eliminated with alcalase enzyme solution after 10-12 h of incubation (Horvath, 1977, 1980) or directly after fertilization using proteolytic trypsin or alcalase (Legendre *et al*., 1996). The eggs' hatching is expected to be in 2.5-3 days (60 degree-days) after fertilization at 22-23°C, 1-day-old embryos weigh 2.6 mg each (Kouril *et al*., 1995; Linhart *et al*., 2002).

This study was carried out to establish traditional production method for artificial breeding of European catfish, *S. glanis*, in Turkey.

MATERIALS AND METHODS

The experiment was conducted in Keban District Production Facility of Government Water Works of Turkey.

Broodstock handling and carp pituitary injection: Fish were kept in brood fish ponds, 1600 m^2 and fed until summer. Stock intensity was 8 (40-50 brook ha^{-1}) per pond. Brooks were selected for stripping as they reached sexual maturity and spawning at 20°C. Water temperature was also awaited and expected to reach 20°C. A couple of male and female were taken into salt+water solution (2.5%) then loaded in pound at 24°C. After 24 h fish were injected with at 0.5 mg kg^{-1} body weight carp pituitary. After 11 h the main dose was applied to brooks as 4 mg kg^{-1} body weight to female and 3 mg kg^{-1} b.w. to males. Stripping was done 13 h later, after the main dose. Before injection and gamete collection, the males and female were anaesthetized in a solution of 2- phenoxyethanol (1: 1000).

The diameter of the eggs was measured in Von Bayer after fertilization. After absolute fecundity per fish was measured, 1 g egg was scaled and counted. The relative fecundity (eggs per unit fish weight) was counted.

Artificial insemination and eggs stickiness elimination: After the fecundity measurement, eggs were separated in 3 plastic volumetric containers. Every female's eggs were kept in 3 plastic containers. These eggs were fertilized by the two male fish. The sperm was stored at 4°C for 4 h. The sperm concentration was determined with Thoma cell hemocytometer under microscope (400x) and mean number was expressed as per 20 squares of Thoma cell. Ova and sperm were mixed in a solution made of 0.3% NaCl for fertilization. The volume of activating solution was 50 mL/100 g of ova. The mixture was stirred for 10 sec and then 2 min later, an additional 25 mL of activating solution was added.

Fertilized eggs were grouped in 200 g parts and loaded in zuger jars, having 7 L each. Water temperature was at 23±0.5°C and flow rate was 3 L for per minute (3 L min^{-1}) during incubation. The stickiness of the eggs was removed by treatment with alcalase enzyme (Merck EC 3.4.21.14), (20 cm^3, diluted in 980 mL of hatchery water) 10 or 12 h after fertilization enzyme was added to eggs, volumetrically 1:1 and stirred for 2 min. Then eggs, decanted and rinsed with water, were loaded in Zuger jars at a rate of 40.000 eggs/7 L.

Evaluation of egg incubation quality by comparison of fertilization and hatching rates: The same approaches to artificial insemination were assessed by results of fertilization and hatching rate, prelarva, postlarva and feeding survival rates as followed: 3 g of eggs were placed into a 1 L coni. For each female, the procedure was replicated three times. The eggs were counted in each coni and, later during incubation the dead eggs and hatched fry were counted, usually up to 3 days of incubation.

The percentage of fertilization rate (%F_r) was calculated for each coni by removing the dead eggs (E_d) (collected up to 24 h after fertilization) from the total number of eggs placed in coni (E_t), as followed:

$$Fr = [(E_t - E_d)/E_t] \times 100$$

The percentage of hatching rate (%H_r) was also calculated for each coni by dividing the total number of eggs placed in the coni (E_t) by the number of hatched larvae (H_l) as followed:

$$H_r = (H_l/E_t) \times 100$$

The survival rates were calculated with similar formulae at periods of prelarvae and postlarvae and feeding.

Larval rearing: Hatched prelarvae were stocked in 200 L polyester tanks at a rate of 50 individuals L^{-1}. The water flow rate was 5-8 L min^{-1} and temperature was 23±0.5°C in tanks. The larvae were fed with egg yolk, various zooplanktons and chironomid larvae for a week. After 2 replicate groups were established, first group postlarvae were kept at a rate of 300 individuals/200 L in these polyester tanks and fed only with tubifex and carp feed containing 35% protein. Second group postlarvae were stocked as 9-11 individuals per each m^2 in earthen ponds, fertilized with organic and inorganic manures. These earthen ponds were fertilized with organic manure (5 kg ha^{-1}), ammonium nitrate (150 kg ha^{-1}) and super phosphate (100 kg ha^{-1}). The water temperature was 22°C in ponds during experiment period. Second group of fish was fed with carp feed, containing 35% protein, at a rate 2.5% of fish-weight for a month. The parameters, related with this study were measured and calculated for each group at the end of a month. After a month only the second group fish in earthen pond were carried out until the 105th day of experiment (the end of summer season) for tracking growth in earthen ponds of catfish. Stock intensity in earthen ponds was 9-11 individuals per each m^2 and larvae were fed with commercial carp feed, containing 35% crude protein. Daily food consumption amounts were recorded for each group. The fish were randomly taken from each group for measurements. At the end of the feeding period, survival and growth parameters were calculated for each group.

In this study, mg values in weight and mm values in length measurements were used. Formulae recommended by Bagenal and Tesch (1978) and Cushing (1968) were used for calculation of condition factor and food conversion rate of groups.

Comparison of groups for each parameter was performed using the independent t-test by the SPSS software package.

RESULTS

Fecundity: Ovulation was stimulated after 13 h from the pituitary injection (3-4.5 mg kg^{-1} b.w.) at 23±0.5°C. The hour-grade for the ovulation of fish was 299-312. 160,000-200,000 eggs were obtained from a female as individuals. The relative fecundity was found as 20519±1658 (Table 1). The diameters of unfertilized and fertilized eggs were calculated as 2.37±0.06 and 3.2±0.05 mm, respectively (Table 1). The color of sperm obtained from male fish was dark-white color. As soon as the fertilized eggs were put in zuger jars, they sticked to one another and to the surface of zuger jar. The mean as volume of collected

Table 1: Total fecundity (eggs/fish), relative fecundity (eggs/kg), egg diameter (mm), spawning weight, the amount (as volume) of sperm and number of spermatozoa per kg body weight (b.w.) after injection of CP at a rate of 3-4.5 mg kg^{-1} b.w. for brood stock in the two experimental groups

Parameters	Group 1*	Group 2**
Weight of female fish (kg, n:2)	11	7
Total fecundity (eggs/fish)	200,000	160,000
Egg weight (mg)	5.04±0.05	5.0±0.05
Total weight of eggs (g)	1000	800
Diameter of unfertilized egg (mm)	2.41±0.06	2.34±0.06
Diameter of fertilized egg (mm)	3.24±0.06	3.16±0.04
Relative fecundity (eggs/kg)	18,181	22,857
Weight of eggs (g)	90.9	114.2
Weight of male fish (kg, n:2)	22	18
Volume of sperm (mL kg^{-1}-b.w.)	2.04	1.94
Number of spermatozoa (10^9 kg^{-1}-b.w.)	0.14	0.13

*experiment in polyester tank, **experiment in earthen pond

Table 2: The percentages of fertilization and hatching of eggs and survival rates in prelarva, postlarva and feeding phases of experimental groups

			Survival rates (%)				
	Number[a] of eggs X±S.D.	Fertilization X±S.D.	Hatching^{D3} X±S.D.	Prelarva^{D5} X±S.D.	Postlarva^{D7} X±S.D.	Feeding^{D30} X±S.D.	Feeding^{D105} X±S.D.
Group 1	644.6±7.5	90.1±1.4	84.4±1.1*	79.5±1.9*	77.1±1.4*	73.1±1.2*	-----
Group 2	652.3±9.0	88.1±1.7	74.7±1.1	72.8±1.5	56.4±1.4	13.4±0.9	9.4±0.8

(Group 1: In polyester tank, Group 2: I earthen pond), ^{D3} = 3rd day; ^{D5} = 5th day; ^{D7} = 7th day; ^{D30} = 30th day; ^{D105} = 105th day, [a]initial number of eggs, S.D.: Standard Deviation, *Significantly different from that of earthen pond ($p<0.05$) (Student t-test)

Table 3: The growth parameters [weight (W, mg), length (L, mm), condition factor (C), Specific Growth Rate (SGR)] and Food Conversion Rate (FCR) of experimental groups (n = 50)

Age (days)	Growth parameters	Group 1[a]	Group 2[b]	t-test and qi-square
0	W*	7.04±0.2	7.01±0.2	
	L	7.28±0.1	7.01±0.2	
7	W±SE	39.5±1.5	37.9±1.4	3.76
	L±SE	16.6±0.6	16.2±0.4	2.34
30	W±SE	3608.0±12	1786.0±25	168.90
	L±SE	20.63±0.4	53.6±0.7	157.50
	C±SE	1.3±0.02	1.2±0.02	0.00
	SGR (%)	15.3±0.45	12.7±0.62	0.60
	FCR	2.3±0.05	2.5±0.06	0.00
105	W±SE	-	74200.0±264	
	L±SE	-	163.0±4.3	
	C±SE	-	1.7±0.04	
	SGR (%)	-	3.58±0.07	
	FCR	-	2.7±0.05	
General	C	1.30	1.45	
	SGR (%)	16.8	8.14	
	FCR	2.3	2.6	

*Corporate rhythm is done because of the fishes to be smaller than the size necessary for measuring, [a]The experiment in polyester tank, [b]The experiment in earthen pond

sperm was in the range of 1.94-2.04 mL kg^{-1} b.w. per sampling. The male fish produced spermatozoa per kg b.w. sperm at a rate of 0.13-0.14[9] (Table 1).

The survival rates of eggs and larvae: The ratio of fertilized eggs was calculated as 89.1% (Table 2). The ratio of dead eggs ranged from 15.6-25.3% during incubation. The posthatching phase was observed in the 3rd day of fertilization at 23.5±0.5°C. The hatching phase was calculated as 69-72 days $degree^{-1}$. After hatching, prelarvae were immobilized and stayed in the bottom of a tank. After 2-3 days from hatching, the pigmentation of larvae started and negative photo-taxi was observed. The larval deaths materialized between 1.9-4.9% during this period. Swimming and feeding of larvae started after 5 days of hatching. Larval death was observed at the rate of 2.4-16.4% in these larvae, fed with zooplankton and egg yolk during a week (Table 2). After this phase, for the larvae farmed in fertilized earthen ponds, death ratio was found as 43% after a month. However, it was calculated that 4.0% larval death occurred in larvae farmed in polyester tanks in the same period (in a month) (Table 2). After a month, the death ratio was 4.0% in the fish fed in fertilized earthen ponds during 75 days (at the end of summer). The difference of fertilization ratio was found insignificant between the two experimental groups ($p>0.05$). However, the differences of the other parameters, related with survival rates of eggs and larvae, were found significant between 2 groups ($p<0.05$).

The growth of larvae and fry: The weight and total length of newly hatched alevins were 7.01-7.04 mg and 7.01-7.28 mm, respectively (Table 3). The weight and total length of larvae in polyester tank and earthen pond for a month were found as 3608 mg -20.6 mm and 1786 mg -5.3 mm, respectively (Table 3). Significant differences were found in all other growth parameters ($p<0.05$) except for condition factor and FCR ($p>0.05$) between 2 experimental groups. The weight, total length and FCR of fish in the earthen pond were calculated as 74200±264 mg, 163±4.3 mm and 2.7, respectively, at the end of the study (after 105 days) (Table 3).

DISCUSSION

This research is focused on spawning and larval rearing of European catfish under hatchery conditions in Turkey. Brood fish aged from 4-8 years were taken from growing ponds in April and the sexes were kept separately in 2 ponds and were given *Cyprinid* fish food, at a rate of 4 kg food kg^{-1}-b.w. of catfish (Steffens *et al*., 1994).

The preferable weight for brood fish of European catfish is 6-10 kg for optimum larvae production (Pillary, 1993).

Individual brood fish suitable for stripping were selected in May-July (20-25°C) and kept isolated in 100-200 m^2 ponds. Males and females were injected with 1-4 mg kg^{-1} body weight of carp pituitary; otherwise no other thing was injected in semi-control methods.

The achievement of semi controlled system depends on environmental and feeding conditions in production. However, in full controlled system, all requirements (environmental and feeding) of larvae were provided at maximum level. In this study, the survival and growth ratios of larvae obtained from 2 females were determinated to produce larvae under full controlled conditions. The pituitary doses treated to brood fish were similar to those of Pillary (1993), Linhart *et al.* (2002) and Hovart (1977), as obtained from their reports. Ovulation period was similar to (430-500 degree-hour) those of Pillary (1993). The Activation Solution (AS), used by Hovart (1977), 0.3% NaCl was used in this trial for fertilization.

The most critical point in the artificial propagation of European catfish was deprived of sperm (Linhart *et al*., 1986). The mean volume of collected sperm was in the range of 1.94-2.04 mL kg^{-1} b.w. per sampling. The males produced sperm 0.13-0.14^9 spermatozoa per kg body weight. The achievement of fertilization done with this sperm was found as approximately 90%.

The artificial propagation of European catfish has been recently improved by techniques developed in the Czech Republic and in France (Linhart *et al*., 2002, 2004). In this method males and females are treated minimally by 4-5 mg kg^{-1}-b.w. of CP or by 40 μg kg^{-1} of LHRHa or Ovopel (LHRHa,D-Ala^6 manufactured in Hungary) (Brzuska, 2001). Male spermiation can be sustained by weekly CP injection during a period of 1 month.

In this study, there was no observed problem related with spermiation. The amount of sperm was greater than that of Linhart *et al*. (2004). This positive factor could be related with brook conditions, the length of adaptation period and environmental conditions.

The sperm should be collected in the IS (170-200 mM NaCl, 30 mM Tris-HCl, pH 7) at a ratio of 1:1 (sperm: IS) to prevent inactivation of spermatozoa by urine and can be stored for 3 days at 4°C (Linhart and Billard, 1994). The ovulated oocytes and sperm are mixed together and activated by AS of 17 mM NaCl, 5 mM Tris-HCl, pH 7 at an optimum temperature of 21-23°C. Ova contaminated by urine during stripping should be discarded (Linhart and Billard, 1995). Two milliliters of sperm +IS (usually lightish white color) with a minimum concentration of 0.08.10^9 mL^{-1} spermatozoa plus 50 mL of AS are optimal to fertilize 100 g of eggs. These are mixed together during 10 s and, 2 min later, another 25 mL of as is added in. For elimination of egg stickiness, alcalase enzyme is used 3 min after the fertilization. Optimum ratio between eggs and diluted enzymes (20 mL of alcalase enzyme, diluted in 980 mL of hatchery water or AS) is 1:1 (gram of eggs/milliliters of enzymes) with stirring for 2 min. After 2 min of exposure in enzyme solution, the eggs are rapidly rinsed with hatchery water and transferred to Weis jars. The use of optimal procedures results in stable hatching rates of 90-100% during stripping, activation of gametes, fertilization and elimination of egg stickiness (Linhart *et al*., 2002, 2004).

Survival rate was found as 79.5% during incubation. The hatching period of eggs was 3 days at 23.5±0.5°C.

The larvae in prelarval phase had a tendency to escape from light in polyester tanks. Survival rate was determined as 76.2% in this period. The larvae finished its yolksac after 5 days of feeding with *Monia* and *Daphnia* zooplanktons and egg yolk and chironomid larvae. This feeding period in hatchery continued for a week. Survival rate was found at a range of 56.4-77.1% in this period. When the larvae released to earthen ponds, survival rates were determined as 13.4% at the end of 1 month and 9.4% at the end of experiment. However, survival rate of the larvae fed with tubifex and carp food in polyester tank during 1 month was found higher (73.1%) than that of

larvae in earthen pond. Survival during the first phase was reported as 10-50% by Linhart *et al.* (2002). Akbay (2001) declared that survival rate of catfish fed with various zooplanktons and granule food (40% crude protein rate) was found as 33% in earthen pond during one summer period. The nourishment of catfish under fully controlled conditions for 3-4 weeks will increase survival rate of fish. While the fish released to earthen pond reach 1.55±0.16 g of weight at the end of 1 month, other fish fed in polyester tank reached 3.6±0.08 g in the same period. The survival and growth rates differences between experimental groups were found significant ($p<0.05$). The results of experiment during one summer in earthen pond were similar to the results of Linhart *et al.* (2002) and Akbay (2001). According to results of some other studies (Fuelluer and Pfeifer, 1995), tubifex had importance in feeding catfish. In addition, larvae's getting accustomed to granulated food in early period is among one of the most important factors and it positively affects survival and growth. Hamackova *et al.* (1998) reported that survival rate at a range of 74.7- 85.4% was obtained after catfish got accustomed to 3 different granulated foods in the 19 days feeding period. In order to increase survival and growth rates of catfish, feeding should be in fully controlled hatchery at least for 1 month. In this study, the food conversion rate was found in average as 2.6 at the end of summer season. This rate was found relatively higher in other studies (1.1-2.2) (Linhart *et al.*, 2002; Hamackova *et al.*, 1998). The cause may be the application of high protein foods in the other studies. Steffens (1981) reported that, catfish average which is 178 g reached 580-600 g with good feeding in cage, 20-30°C, at the end of 3 months. In extensive fish farming in Czech Republic, catfish were stocked at a rate of 100-150 fish ha^{-1} along with 2-years-old carp reached 1.5-3 kg at the end of two years and its harvest yield were 10-20 kg ha^{-1}. The production of European catfish in Czech Republic in closed thermo regulated systems and total annual harvest from aquaculture increased from 2-96 t between 1993 and 1999 (FAO, 1999a, b). In the farm which used recirculation system, catfish are reached to 4 kg market-size at 20-22°C at the end of 1.5-2 years. However in France, several production systems are in use; intensive, in geothermal water, in cages (density 15 kg m^{-3}) or in 500 m^3 ponds (up to 20 kg m^{-3}). The market size (1.5-3 kg) is reached after 2 year in warm water 25-28°C and 3 year at ambient temperature 8-25°C (Linhart *et al.*, 2002). The regions, having >20°C of water temperature during 8 months of year are available in Turkey. In these warm waters, it is possible to carry-out intensive farming of catfish as an alternative to carp.

As a result, catfish may become an important specy because it can easily get accustomed to artificial food and can reproduce in fully-controlled systems as well as in natural-waters of Turkey and can be farmed as mono-culture in carp ponds in freshwater fish farming in Turkey.

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