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Research Note / Araştırma Notu

Survival Rates of Common Sole (*Solea solea* L.) Captured by Gill Nets and Trawl from İzmir Bay; Adaptation to Culture Conditions and Feeding Behavior

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Özet: ***Trol ve uzatma ağları ile İzmir körfezinden yakalanan dil (*Solea solea*) balığının yaşama yüzdesi; kültür şartlarına adaptasyonu ve beslenme davranışı.*** Bu araştırmada, doğal ortamdan yakalanan dil balığının (*Solea solea*), kültür şartlarına adaptasyonu ve beslenme davranışı incelenmiştir. Dil balıkları, 2007 Mart-Nisan döneminde, İzmir Körfezi'nden trol ve uzatma ağlarıyla yakalanmıştır. 270 adet dil balığının ön adaptasyonu sırasında, ilk beş gün boyunca, karanlık ortamda antibiyotik (100 ppm fruzolidon ilavesi, 60 dak/gün) uygulaması gerçekleştirilmiştir. Kültür şartlarında ilk besleme için, kalamar (*Loligo vulgaris*), boru kurdu (*Diopatra neopolitana*), kara midye (*Mytilus galloprovincialis*), sülünes (*Solen marginatus*), istiridye (*Ostrea edulis*), japon şapkası (*Patella spp.*), deniz salyangozu (*Monodonta turbinata*) ve taze sardalya (*Sardina pilchardus*) kullanılmıştır. Dil balıkları 0-2 gün içinde beslenmeye başlamıştır ve boru kurdu, en çok tercih ettikleri tür olmuştur. Bir aylık adaptasyon dönemi sonunda, uzatma ağlarıyla yakalanan dil balıklarının yaşama oranının (%58), trol ile yakalananların yaşama oranından (%29) önemli düzeyde yüksek bulunmuştur ($p < 0.05$).

Anahtar Kelimeler: Dil, yaşama yüzdesi, adaptasyon, beslenme davranışı.

Abstract: Adaptation to culture conditions and feeding behaviour of common sole (*Solea solea*), which caught from natural environment, were investigated in this research. Soles were captured in March-April 2007 period from Izmir Bay by trawl and gill nets. During preliminary adaptation of totally 270 soles, antibiotic treatment (furozolidon added 100 ppm for 60 min./day) was applied for first five days in dark environment. In culture conditions, squid (*Loligo vulgaris*), long-yawed plume worm (*Diopatra neopolitana*), mediterranean mussel (*Mytilus galloprovincialis*), razor clam (*Solen marginatus*), oyster (*Ostrea edulis*), patella (*Patella spp.*), sea snail (*Monodonta turbinata*) and fresh sardine (*Sardine pilchardus*) were used for first feeding. Soles started to feed in 0-2 days and long-yawed plume worm was the most preferred species. After adaptation period of one month, the survival rate (58%) of soles which were caught using gill nets was found out significantly higher than the survival rate (29%) of soles which were caught using trawl ($p < 0.05$).

Key Words: Common Sole, survival rate, adaptation, feeding behaviour.

Introduction

The common sole (*Solea solea*, L. 1758*)* is an interesting new species for marine aquaculture in Europe as it is a high valued species with large market (Schram et al., 2006, Bernardino 2000, Barbato and Corbari 1995, Palazzi et al., 2006, Gilliers et al., 2006, Brown 2002). *Solea solea* and *Solea senegalensis* are two common soles of Atlantic and Mediterranean area, and they have been used as alternative species in marine aquaculture (Dinis and Reis 1995, Dinis et al., 1996, 1999, Bernardino 2000, Yufera et al., 1999, Imsland et al., 2003). The common sole is one of the teleost flatfish and belongs to the family Soleidae (Dinis and Reis 1995, Mengi 1971, Turkmen 2003). In Turkiye, its geographical range extends from West Black Sea to East Mediterranean Sea, including the Sea of The Marmara (Basusta et al., 2002, Mengi 1971, Hossucu 1992, Turkmen 2003). This species is distinguished by right side located eyes, flattened body by both sides and dorsal and anal fins surrounding body. It habitats on sandy and muddy bottom and can reach depths of up to 100 m (Kruuk 1963, Mengi 1971, Hossucu 1992, Nasir and Poxton 2001).

Common sole is a nocturnal and olfactory feeder, spending the day buried in bottoms with sediment. The side without eye of sole has many sensory organs to facilitate prey detection (Lagardére 1987). It feeds on bottom fish, crustaceans and bivalves (Mengi 1971, Whitehead et al., 1986, Lagardére 1987, Hossucu 1992, Dinis and Reis 1995, Dinis et al., 1999, Reig et al., 2003). Extreme and optimal water temperatures and salinity for common sole is 1 ºC and for ‰ 5 for minimum; 30 ºC and ‰70 for maximum and 18 – 20 ºC and ‰ 35 for optimum respectively (Hossucu 1992). Studies on stomach contents of *Solea solea* displayed a dominance of *Polychaetes* but some *Amphipods*, *Copepods* and *Isopods* were also identified. The results of Dinis and Reis (1995) based on the work of Fluchter and Trommsdorf (1974), showed the importance of *Polychaetes* in the feeding regime in captivity of *Solea solea*.

There are few data on the adaptation to culture conditions and feeding behaviour of this species in aquaculture of Turkey. One of the main requirements for appropriate culture and management procedures for the broodstock is complete control transportation and adaptation (Billard et al., 1981, Pickering 1993, Bromage and Roberts 1995, Basaran and Samsun 2004). The physical injury and physiological stress of capturing, handling, injecting and holding brood fish can individually and collectively have negative effects on adaptation, feeding and spawning success (Basaran et al., 1999, Basaran and Samsun 2004). This study has investigated the survival rates of common sole captured by trawl and gill nets, conditions of transportation to culture environment, and feeding behaviour at culture conditions.

Materials and Methods

Experimental fish were captured by trawl and gill nets from similar depths in Izmir Bay by small commercial fishing boats for traditional fishing and marine research boat of Ege University Fisheries Faculty for trawl operation in March and April 2007. Fishing operations with gill nets were accomplished at nights; and trawl operations were achieved with towing speed as ranged from 1.2 to 1.5 knot.hour^{-1}.

Fish captured by trawl operations were placed in dark 300 l. polyester tank which was aerated. For reducing stress, anesthesia treatment (2-fenoxyetanol, 50 ppm) was carried out in transportation tank (Basaran et al., 1999). Fish captured by gill nets were transported in 20 l. thermal isolated tank with continuous water exchange and circulation. After each fishing operation, only live fish were transferred to the shore and total length and total weight of all fish were measured.

On shore, all of the live fish were taken into two separate 4 m^3 square-shape (1.8x1.8x1.3 m) polyester tanks for preliminary adaptation. 20% per hour water exchange was supplied and during this preliminary adaptation period, antibiotic treatment (furozolidon, 100 ppm, 60 minutes.day^{-1}) was carried out for five days to avoid probable infections originating from fishing operations injuries in dark environment. During the first five days, fish were kept in dark conditions and after this period, light intensities in tanks were fixed 30 lux. During this 10 days preliminary adaptation period, water temperature and salinity were fixed 13±1ºC and 38‰ respectively.

In order to determine the preference and the first reaction of the fish to the different diets, eight different diets were introduced to the adaptation tanks. These diets included squid (*Loligo vulgaris*), long-yawed plume worm (*Diopatra neopolitana*), mediterranean mussel (*Mytilus galloprovincialis*), razor clam (*Solen marginatus*), oyster (*Ostrea edulis*), patella (*Patella spp.*), sea snail (*Monodonta turbinata*) and fresh sardine (*Sardina pilchardus*). Consumption of foods was checked following 10 days after the first feeding and diminishing foods were replenished and recorded. Mediterranean mussel, oyster, patella and sea snail were obtained from shallow waters around the facility; and squid, long-yawed plume worm, razor clam and sardine were obtained freshly from fish market.

Total length (cm) and total weight (g) of captured soles were measured and descriptive statistics were determined. Relation between length and weight of fish were expressed with power regression graphic, equation, and correlation coefficient. Significant test of survival rates between two groups was used by *Z-test* (Zar 1996). All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS 9.0) and significance was accepted at p = 0.05.

Results

Both large and small 270 individuals were obtained from nature in March and April 2007. Most of these fish were captured by gill nets and the rest by trawl nets. 16 fish were captured with 5 operations in March and 8 fish were captured with 4 operations in April by trawl; 103 fish were captured with 22 operations in March and 143 fish were captured with 30 operations in April by gill nets. In these operation periods, seawater temperatures were ranged from 14 to 16 ºC in March and ranged from 16 to 18 ºC in April.

Common sole captured by both two fishing methods, were stocked in dark culture environment to start preliminary adaptation. The number of dead fish obtained by two different fishing equipment was recorded daily and survival rates were determined (Table 1.). After one month of adaptation period, 7 of 24 and 144 of 246 individuals were alive captured by trawl and gill nets respectively. The survival rate (58%) of fish captured by gill nets was found higher than survival rate (29%) of fish captured by trawl (p<0.05, *Z-test*).

Table 1. Survival rates of sole, caught by two different fishing methods, throughout one month of culture conditions.

Fishing	March		April		Total of Fishing Operations	Average Survival Rate (%)
	Number of Fishing Operations	Survival Rate (%)	Number of Fishing Operations	Survival Rate (%)		
Trawl	5	25^a	4	37.5^a	9	29^c
Gill Nets	22	63^b	30	55^b	52	58^c

Data in the same column and groups with the same small letter in the superscription are different (*Z-test*, p<0.05) between trawl fishing and gill nets fishing.

Data in the same raw and groups with the same small letter in the superscription are similar (*Z-test,* p>0.05) between two months.

However the survival rates were stated with total of all captured 270 fish, 172 of them were used to declare descriptive statistics. When dead fish were not realized for a few days on the bottom of tank, their shape and dimensions

could change by the time, therefore they were not measured. Fish which were believed to have done no fault on measuring were considered for descriptive statistics. Average weights and lengths of fish were determined 196.68±8.28 g. and 27.89±0.32 cm. respectively.

The power regression graphic of length and weight relation of all fish is presented in Figure 1. Total weight-length power regression equation and correlation coefficient of all fish were found as $W= 0{,}0025L^{3{,}3631}$ and r = 0.98 respectively. A positive allometric relation was found between total weight and total length.

During the feeding studies, it was observed that the common sole prefer long-yawed plume worm over Mediterranean mussel and razor clam. They started to feed on second day of the captivity and they usually fed at nights. First preference of broodstock in 8 different food was long-yawed plume worm and they started to consume Mediterranean mussel and razor clam on third day; fresh sardine, oyster, patella and sea snail on fourth day and squid on tenth day (Table 2).

It is determined that long-yawed plume worm, Mediterranean mussel and razor clam as food for sole could be beneficial to increase the success of adaptation to culture conditions. Also, fresh fish and other mollusk species can be used.

Table 2. The preference of sole in the different food variety.

Species used for food	Days									
	1	2	3	4	5	6	7	8	9	10
long-yawed plume worm (*Diopatra neopolitana*)	x	x	x	x	x	x	x	x	x	x
Razor Clam (*Solen marginatus*)			x	x	x	x	x	x	x	x
Mediterranean Mussel (*Mytilus galloprovincialis*)			x	x	x	x	x	x	x	x
Oyster (*Ostrea edulis*)				x	x	x	x	x	x	x
Patella (*Patella spp.*,)				x	x	x	x	x	x	x
Squid (*Loligo vulgaris*)										x
Sea Snail (*Monodonta turbinata*)				x	x	x	x	x	x	x
fresh sardine (*Sardina pilchardus*)				x	x	x	x	x	x	x

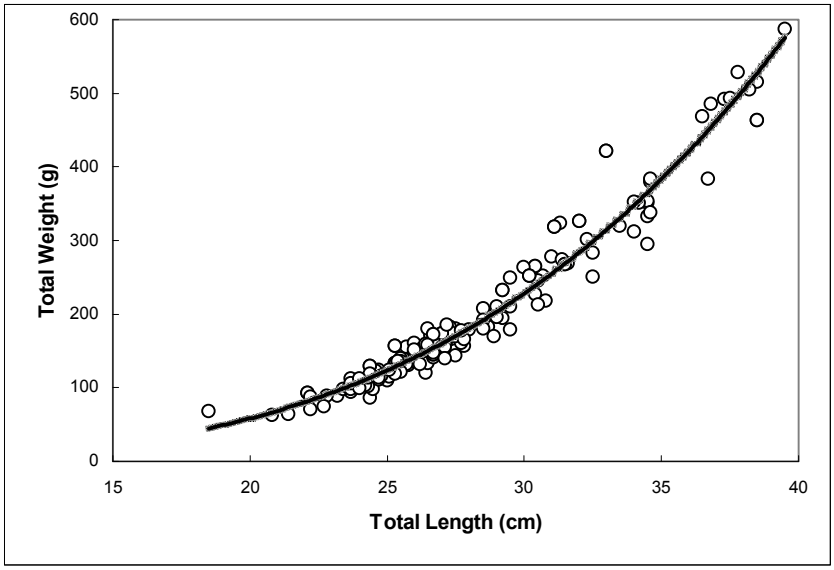

Figure 1. Relation between total weight and total length of all fish (n=172).

Discussion

Many researchers have studied different fishing methods for supplying healthy broodstock before they start to produce the larval fish (Dinis and Reis 1995, Kentouri et al., 1995, Basaran et al., 1999, Basaran and Samsun 2004). Adaptation success of broodstock sole in captivity affects directly high quality and quantity of egg production (Dinis and Reis 1995, Hossucu 1992, Imsland et al., 2003). In Turkiye, the gill net is the most commonly used fishing gear on all sea costs.

Positive allometric growth was observed for all fish (♂+♀) in this study. A high correlation was found between total length and total weight. Similar results have been reported by Hossucu (1992) and Hossucu et al. (1999) in İzmir Bay. In contrast to a maximum total length of 39.50 cm observed in our study, Quero et al. (1986) measured 70 cm as the total length for this species. The sole of large sizes are rarely catch due to the over exploitation of sole in İzmir Bay (Hossucu et al., 1999).

From the result of this study, the highest survival rate of sole caught by gill nets was found 58%. Although mortality of sole caught by trawl is reported to be 50% (Devauchelle et al.,

1987), in our study result show that mortality caught by trawl was determined 71%. This difference may arise from the duration of fishing operation, fishing season and the conditions of transportation. During the transportation of the fish to the culture systems, anesthetics and antibiotics are used by many workers in order to reduce stress and to treat the injuries which cause mortality in fish (Dinis 1992, Kentouri et al., 1995, Basaran and Samsun 2004). It was found that extreme mucous secreting of common sole was seen in transfer to on shore after the capturing. Applying of 2-phenoxyethanol (50 ppm) during transfer for 2–4 hours was not found to be negative effect and antibiotic (furozolidone) treatment provided good results in the hemorrhagic areas of the fish during the transportation (20-50 ppm) and adaptation (100 ppm, 60 minutes.day^{-1}) trials. Similar results were found by Basaran and Samsun (2004) in the adaptation study of turbot. The survival rate (58%) of fish captured by gill nets was found higher than survival rate (29%) of fish captured by trawl (p<0.05, *Z-test*).

Good adaptation and appropriate food regime seem to be prior condition for a correct broodstock management and the obtaining of natural spawning with good quality eggs. Many authors agree in describing a trophic profile for *S. solea* mainly composed of polichaeta and molluscs (Braber and Groot 1973, Reig et al., 2003), as well as crustaceans (Molinero and Flos 1991, 1992). In the present study, it was found that sole must feed with long-yawed plume worm for the first feeding to obtain good adaptation success to culture conditions and similarly, same results were reported by Dinis (1999) named the "Polychaetes effect". It is well known that sole has a nocturnal feeding ability and they remain inactive in the sand the whole day (Appelbaum and Schemmel 1983, Harvey 1996, Kruuk 1963). Although the time of feeding was not the main objectives of the study, giving time of the diets for first feeding of sole in the culture should be taken consideration close to night time. If the diets were given into the tank in the morning, they could have potential to lose freshness and attractiveness until the night period. Present study showed that first feeding behaviour has only taken place during the night in the culture conditions.

In conclusion, the current results showed that fishing operation with gill nets was an effective and reliable way for the adaptation to culture conditions of sole. During the transportation and adaptation, antibiotic treatment (20-50 ppm and 100 ppm, 60 min.day^{-1}, respectively) has positive effects to supply better acclimation conditions. Choosing of first diet for intake the culture tank was the most important character for adaptation success and feeding time also was important to increase the performance.

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