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Sea Bass (*Dicentrarchus labrax* L., 1781) Seed Production

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Abstract

Sea bass seed production of Turkey has increased rapidly in the last 5 to 6 years, which is comparable to those of some Mediterranean countries and has reached the level of approximately 50 million fry in 2001. However, seed production of this species is not expected to increase in the near future because of the market saturation and the fall in the price of the final product.

Recently, the survival, growth rates and the quality of sea bass fry have improved considerably as a result of technical advances in larval rearing. Nevertheless, more efforts are necessary to reduce production cost of juvenile. With the current crisis on *Artemia*, the importance of compound diets as alternative larval food is recognized.

This paper provides some important aspects of the culture techniques for sea bass juvenile production, the characteristics of the rearing systems and culture techniques adapted in commercial hatcheries. Moreover, some research activities are geared to make the culture techniques economically viable. The results of the studies on "off-season spawning" using photoperiod and on weaning the larvae from *Artemia* to compound diets are also presented.

Key Words: sea bass, *Dicentrarchus labrax*, rearing systems, culture techniques, photoperiod, Aegean Sea.

Introduction

Fish culture in the Mediterranean is essentially based on two species, sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). Their commercial production accelerated in the late 1980s and reached 87,000 metric ton (mt) in 1999 and 107,000 mt in 2000. The share of sea bass production was 47,600 mt in 2000 (www.feap.org; Fish Farm. Int., April 2001). Sea bass and gilthead sea bream represented the largest marine fish farming industry in Europe, with a production of approximately 450 million fry in 1999. The European Union played a major role in the development of this fish farming sector, both by supporting applied research activities and subsidizing aquaculture investments in southern Europe (Harache and Paquotte, 1998). There are currently around 90 sea bass and sea bream hatcheries in Europe, most of which produce approximately 1-5 million fry per year for their own use. Approximately 10 commercial hatcheries with a production of >10 million fry per year exist (Shields, 2001).

Commercial production of sea bass and sea bream in Turkey started in the late 1980s; but the greatest developments occurred in the last 5 to 6 years (Table 1).

There are 18 hatcheries in Turkey, all of which produce sea bass fry with only 11 of these producing both species. Yearly production of most sea bass hatcheries ranged from 0.5 to 5 million fry (Table 2). Total sea bass production in Turkey was approximately 50 million juveniles in 2001 (Table 2).

Although, most of the hatcheries have their own broodstock, production of sea bass juveniles is only for a short period, from April to July due to the market demand. Although at present, the hatchery production of sea bass juveniles can meet the demand of farmers, their production depends on the rate of demand and on the price variations. Thus, some of the hatcheries has decreased or simply stopped their sea bass culture operation, mainly due to the fall in price around 13 cent/fish at the start of 2002.

The precise rearing techniques for sea bass in European hatcheries vary according to geographic region, number of species reared, and the scale and sophistication of the hatchery. French researchers established highly specific rearing protocol for sea bass taking into consideration the tank characteristics, lighting conditions and water surface treatment (Chatain, 1997). Most hatcheries, both sea bass and sea bream are produced in a shared facility with substantial overlap in husbandry procedures, i.e. the use of microalgae and rotifers during first feeding (Shields, 2001). The intensive production of sea bass larvae in closed water systems, without microalgae has been described by Coves *et al*. (1991). This rearing method named "the French Technique" has also been used by majority of the hatcheries in Turkey.

Broodstock Management

Broodstock is the gene source of millions of juvenile fish. Thus, it has to be constituted from the

Table 1. Annual production (tonnes) of cultured sea bass (*D. labrax*) and sea bream (*S. aurata*) in Turkey from 1990 to 2000 (Source: Ministry of Agriculture and Rural Affairs of Turkey).

Species	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Sea bass	102	777	808	3,158	2,229	2,773	5,210	6,300	8,660	12,000	17,877
Sea bream	1,031	910	937	1,029	6,070	4,847	6,320	7,500	10,150	11,000	15,460

Table 2. Sea bass seed production of Turkey by the Hatcheries (Source: Ministry of Agriculture and Rural Affairs of Turkey, 2000-2001 production records).

Name of the company/institution	Location of hatchery	Years	
		2000	2001
Akuvatur Su Ürünleri	Adana	6,000,000	6,500,000
Akuva-Tek Su ürünleri	Bergama-İzmir	2,500,000	200,000
Amma	Bodrum -Muğla	------	3,100,000
Beymelek	Kale-Antalya	400,000	400,000
Egem Deniz Ürünleri	Aliağa-İzmir	500,000	650,000
Ege-Mar	Didim-Aydın	5,000,000	7,000,000
Elektrosan Deniz Ür.	Foça-İzmir	1,200,000	500,000
Güven Balık Ür.	Karaburun-İzmir	2,000,000	------
Güvercinlik	Bodrum-Muğla	1,000,000	1,000,000
Hakan Su Ürünleri	Bodrum-Muğla	2,200,000	------
Hatko Su Ürünleri	Milas-Muğla	1,000,000	2,000,000
İda Gıda	Çanakkale	1,000,000	1,000,000
İlknak	Dikili-İzmir	------	6,000,000
Kılıç Su Ürünleri	Milas-Muğla	6,000,000	12,000,000
Mordoğan Su Ürünleri Paz	Karaburun-İzmir	------	------
Pınar Deniz Ür.	Çeşme-İzmir	7,000,000	6,500,000
Teknomar Su Ür.	Aliağa-İzmir	2,000,000	500,000
Turkuaz Marin Deniz Ür.	Bergama- İzmir	-----	3,000,000
Total Production		37,800,000	50,350,000

individuals having superior genetic characteristics. To this purpose, it is of high importance to tag broodstocks and monitor their performance.

Biotechnological approaches on broodstock management: Biotechnologies which have significant potential application for broodstock improvement include chromosome set manipulation, gene transfer, and marker-assisted selection (Bromage, 1995).

Because of the elevated proportion of male sea bass obtained from hatcheries and their poor growth performance compared with females (Carrillo *et al*., 1995), some research activities on their sex control (i.e. production of female individuals) have been carried out in recent years (Felip *et al*., 1999; Peruzzi and Chatain, 2000). These include triploidy and gynogenesis and the growth and gonadal development of triploid fish. Moreover, studies on selection of genetic marking to obtain individuals with greater environmental tolerance, disease resistance and growth rate have also been carried out (Garcia de Leon *et al*., 1998).

Determination of stock size and it's management: The number of captive broodstock depends on the target production of the hatchery. Thus larval survival rate of weaned fry should be known with due consideration of the efficiency of rearing conditions.

The optimal age of female broodstock for spawning ranges between 5 and 8 years, whereas for males is 2-4 years. For natural spawning, broodstock are generally stocked in floating cages or in large ponds for the long term maintenance.

If the fecundity of female fish is supposed to be 300,000 eggs per kg. body weight, 200,000 – 220,000 viable larvae per kg body weight (BW) could be obtained. But, to give allowance for any possible losses during spawning season, a safety margin in stock size is considered. Average larval production of female fish per season is supposed to be 120,000 2 days old larvae per kg BW (Moretti *et al*., 1999) for stock dimensioning.

Two distinct feeding regimes are used for broodstock maintenance. These are:

a) Maintenance feeding

This is carried out from the end of the spawning season till the onset of the vitellogenesis (from May to October). Fish are fed with pellets at a rate of 0.5% of biomass/day. These pellets contains: protein >46%, lipid >12%. If available, fresh feed (fish-by-catch) is given twice a week at a rate of 1.0% biomass/day.

b) Enriched feeding

If broodstock diets contain adequate ratios of unsaturated fatty acids (DHA/EPA/AA), the egg and larval quality are improved. Neural function and visual performance of larvae are maximized and then physiological function becomes efficient (Bell *et al*., 1997; Bromage, 1995; Bruce *et al*., 1999). Thus, a special diet is provided during period of vitellogenesis (Oct.-Dec.) when there is increased gonadal development. These enriched pellets are given at 0.5% of biomass/day and contain: protein >45%, lipid >16%, n3 HUFA >40 mg/g dry diet, DHA>26 mg/g, EPA >13 mg/g, Carbohydrates <15%.

Fresh feed (cuttle fish, common squid, trash fish) is also used at a rate of 1.0% of biomass/day.

Reproduction

Sea bass uses seasonal photoperiodicity to synchronize spawning. Temperature has an effect on the rate of vitellogenesis and acts as minimum/maximum threshold for spawning. The reproductive process includes many hormonal changes and different physiological activities for the fish. After the sexual resting period (April-May), sea bass gonads undergo pregametogenesis (June-September) and gametogenesis phases (Prat *et al.*, 1990).

The initiation of gametogenesis usually occurs under the effect of decreasing photoperiod at temperature kept below 26°C (Devauchelle and Coves, 1988). The duration of oocyte growth till maturation is linked to temperature as well as to photoperiod. Oocytes larger than 650µm are first observed 4 to 5 months after the onset of gametogenesis. The maximum number of eggs is obtained at spawning temperatures of 13 to 16°C.

If females with oocytes larger than 650µm in diameter (late-vitellogenic stage) could not hydrate the eggs or if the water temperature is not ideal for natural spawning, hormonal treatment is required. LHRHa (Luteinizing-releasing hormone, LHRH ethylamide, acetate salt) is delivered with two intraperitoneal injections 4-6 hours apart at 5 and 10 µg/kg body weight (BW) dosages, respectively.

Optimal stocking rate is 2 to 3 kg/m^3 with a maximum acceptable load of 5 kg/m^3 (Moretti *et al*., 1999). This stocking rate can be increased in case pure oxygen is injected into the water system. The sex ratio is 1 male to 2 females (Coves *et al*., 1991).

Off season spawning

Off season sexual maturation can be obtained through enrivonmental manipulation using photoperiod and temperature. Different methods are being practiced and these are:

- Fish are kept under reduced photoperiod and temperature cycles (the commonest),
- Fish kept under constant day length are exposed to brief periods of long and short days, (sometimes with artificial cooling of water), or
- Fish live in different 12-month long natural cycles, but shifted by three month each

For the last phase shifting method the broodstock is divided in four groups including both males and females; three groups are exposed to environmental regimes that are shifted by 3,6 and 9 months respectively compared to the natural environmental regime, which is left for the fourth group. In this way, the hatchery will have a group of fish ready to spawn on each season.

If only a short period for fry production and marketing is considered, the first two methods are recommended.

If the fish are exposed to the compressed light and decreased temperature cycles or to the extented light and increased temperatures cycles compared to the natural light and temperature cycles, advanced or delayed spawnings are obtained.

Exposure of fish to a month of long days (15 h light and 9 h dark) in each 24 h cycle in March, April. May, June, or July with constant short days (LD 9:15) for the remainder of the year speeds up the rates of maturation and also advance ovulation. If the water temperatures are higher than the natural spawning temperatures, hormonal treatment or artificial water cooling is required to get sea bass to spawn (Carrillo *et al*., 1995).

Many off season spawning is done by varying the temperature and photoperiod altogether. Since the use of temperature regulator to cool the water in the spawning tanks increases production cost in an off season spawning program, the role of photoperiod to advance or delay spawning of seabass under ambient temperatures (Figure 1) has been worked out at Bodrum Fisheries Research Institute. In the particular 3 year study conducted, fish were grouped into four:

Group 1: advanced spawning with compressed photoperiod (Figure 2)

Group 2: advanced spawning with constant photoperiod (Figure 3)

Group 3: delayed spawning with constant photoperiod (Figure 4)

Group 4: delayed spawning with extended photoperiod (Figure 5)

The fish in the control groups were transferred from the floating cages to spawning ponds two months before spawning. Fish from other treatment groups were kept in the same ponds throughout the year. A hormone injection is administered in all groups except some fish in the control and advanced spawning groups.

The best results in terms of egg productivity, egg quality and reliability in advancing off season spawning was under constant photoperiod (Table 3).

The poorest results were recorded in the groups under the shifted photoperiods for delayed spawning (Table 3). Zanuy *et al*. (1999); Devauchelle and

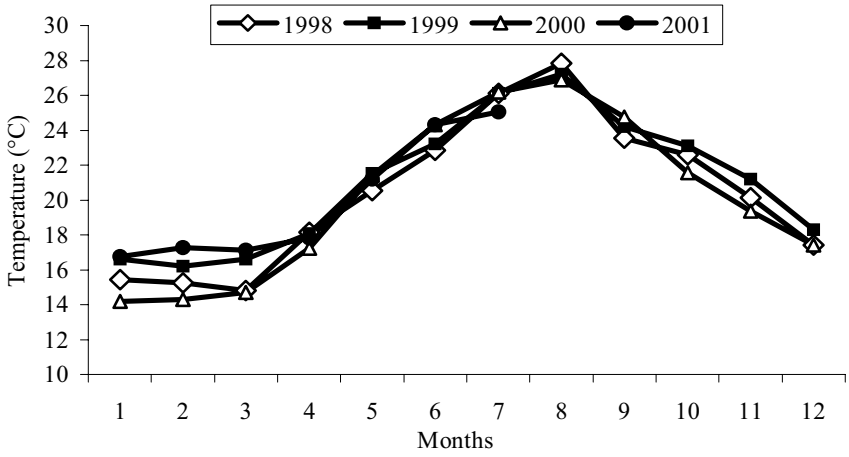

Figure 1. Annual seawater temperature changes; 1998-2001 Bodrum, Güvercinlik Bay.

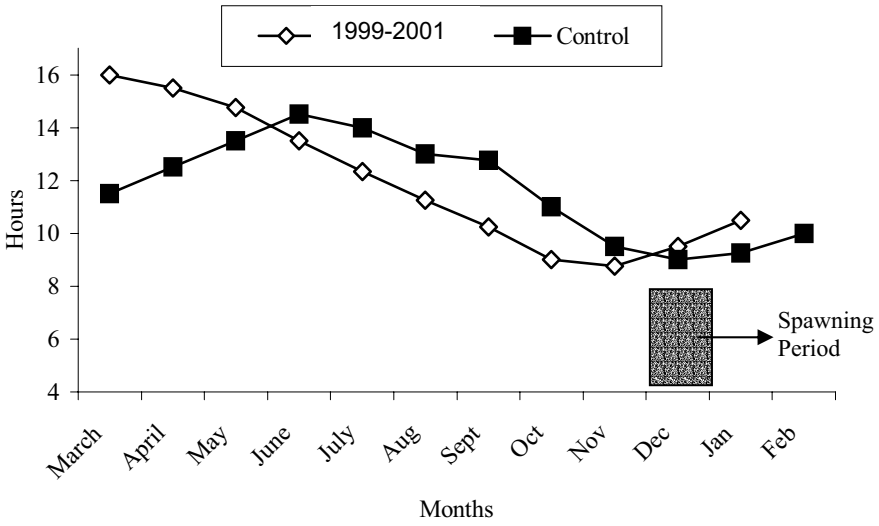

Figure 2. Compressed photoperiod for advanced spawning 1999-2001.

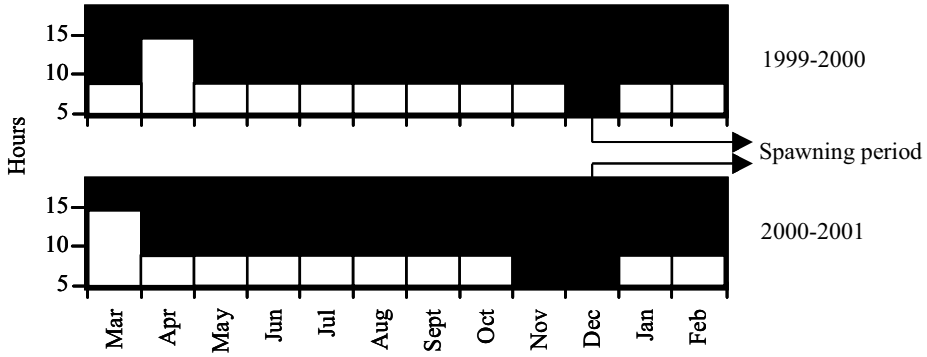

Figure 3. Constant photoperiods for advanced spawning 1999-2001.

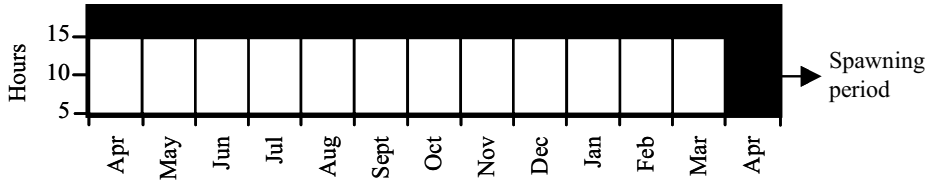

Figure 4. Constant photoperiods for delayed spawning 1999-2001.

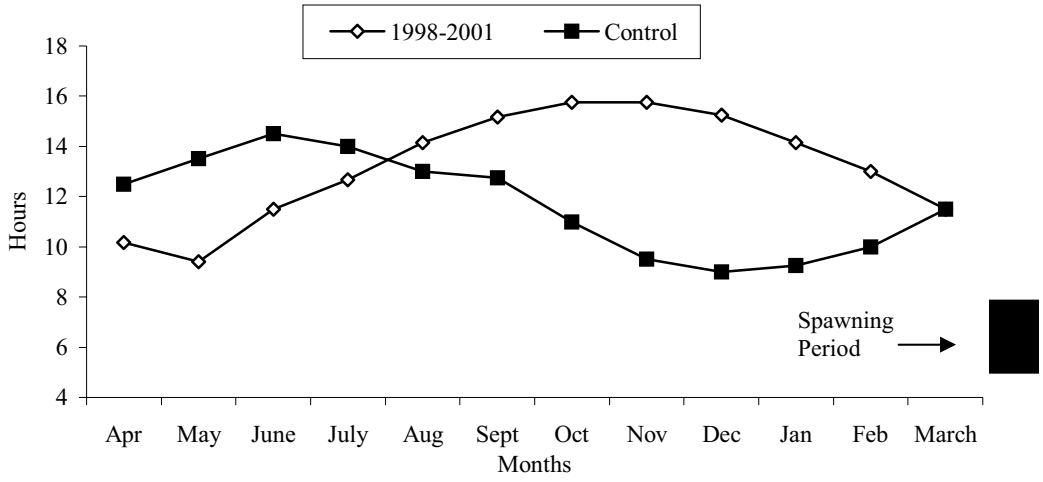

Figure 5. Extended photoperiods for delayed spawning.

Table 3. Spawning performance and egg quality of fishes under normal and shifted photoperiods for advanced or delayed spawning (Büke, 2001).

Groups	Spawning Period	Spawning Temp. (°C)	Egg productivity as number of eggs per kg. b.w.	Dead and unfertilised eggs (%)	Egg diameter (μm)	Central oil droplet diameter (μm)	Egg wet weight (mg)
Control	February-March (0-15th)	14-15	275-285	18-35 (after hormon)	1049-1155	282-357	0.81-0.89
1th group	December	18-16	242-382	18.7-27.3	1047-1122	242-296	0.82-1.05
2nd group	December (0-10th)	18-16	284-382	3.8-21.7	1020-1174	248-377	0.85-1.15
3th group	April (10-20th)	17-18	128	22-38	1041-1112	242-308	0.83-0.90
4th group	April (10-20th)	17-18	120-275	33-39	1055-1105	296-365	0.86-0.96

Coves (1988) and Carrillo *et al*. (1991), all reported poor fecundities and egg survival in photoperiodically-delayed fish. Zanuy *et al*. (1999) and Devauchelle and Coves (1988) have suggested that high (above 17°C) sea water temperatures reduce the quality of spawned eggs. Possibly, the mis-match in photoperiod and temperature regimes may significantly affect the neuroendocrine system of the fish to produce poor quality eggs (Carrillo *et al*., 1995). This can be overcome by artificially decreasing water temperatures from the beginning of April till spawning within a short period when environmental conditions at Bodrum are not suitable.

But, it is possible to obtain "off season spawning" using both advanced and delayed photoperiod programs in areas on the northern Aegean coast, which have lower water temperatures in autumn and spring months.

Collection and incubation of eggs

The fertilised seabass eggs are transfered into the collector placed outside the spawning tank through surface outlet.

Only viable eggs with highest buoyancy are selected, weighed and disenfected with iodofor (50 ppm active iodine for 10 minutes).

Egg incubation is carried out with two different methods:

1. Egg incubation in dedicated facilities: The fiberglass round tanks with conical bottom and a 100 to 250 l. capacity is used. Stocking density ranges from 10,000-15,000 eggs per litre. Water turnover is maintained at one total renawal per hour.

2. Egg incubation in the larval rearing tank: Most of the hatcheries use this method (Çoban, 2000). Eggs are stocked directly into the rearing tanks or into the screened floating containers placed inside the tank. Stocking density in floating containers is kept between 4,000 and 7,000 eggs per litre. Water renewal is 5-10 % of water volume per hour.

Incubation temperatures are between 14 °C and 15°C. Incubation lasts for about 110 h. at these temperatures. The hatching rates are between 80% and 90%.

Larval Rearing

Larval culture covers the entire larval development stages, starting with the newly hatched larvae and ending with metamorphosis. The latter starts on day 30 post-hatch and completed on days 40-45.

Larval rearing facilities

Rearing units include cylindro-conical tanks of 3 to 4 m^3 volume with inner walls painted black. Water inlet is placed at the periphery of the tank. Aeration in the tank is carried out by compressed air. Pure oxygen is also injected to the circulating water. In some of the currently established hatcheries, electronic oxygen control systems are used. Degassing column on each tank inlet is used to avoid oversaturation (N2) risk. Water skimmers are also used to clean water surfaces.

The closed rearing system includes a mixing tank, a sand filter, heating/cooling system, UV disinfection chambers and biological filter (and cartridge filters in some facilities). Where feasible, the use of borehole water rather than pumped ambient water is preferred.

Culture conditions

Temperature is kept at 15-16°C in prelarval period and slowly increased (0.5°C/day) to reach 17°C at the stage of complete swimbladder inflation. Afterwards it is increased to 19-20°C.

Salinity is reduced to 25-26 ppt between 4th and 17th days to enhance survival rate (Chatain, 1987; Dendrinos and Thorpe, 1985; Fırat, 1995).

Very low levels of light intensity (20 lux) is used at the beginning of feeding period It's kept under 100 lux by D-13 and increased to 500 D-17. In the case of swimbladder hypertrophy, it's increased to achieve the downward migration of larvae for swimbladder to inflate normaly.

Photoperiod is 8 hour/24 hour at the beginning, then, it is increased to 16 hour/24 hour also at D-17.

The skimmers used to clean the water surface allow the larvae to inflate the swimbladder and are used at least three times a day from the D-4 to D-20.

The initial water renewal in the larval tanks is 10% of the volume of the tank/hour. It is increased to 20%, 30%, 40% and 50% on the 12th, 20th, 30th and 40th days respectively.

Dissolved oxygen is maintained between 5 to 7 mg/l. Aeration inside the tank is not used before the swimbladder inflation. The pure oxygen is added to the water by injecting this into the water piping system.

NH_3, NO_2, and pH of the water is monitored daily. NH_3 and NO_2 levels should be under 0.5 mg/l and 0.2 mg/l. pH should be above 8 or at very low level enough to stimulate the larvae to migrate downward.

If the hypertrophy syndrome is observed, light density and feeding rate are increased to stimulate the larvae to migrate downward. A 24-hour lighting is applied and continued until at least on D-25.

Initial larvae density is 100,000-120,000 larvae /m^3.

Feeding protocol for sea bass larvae

Feeding of sea bass postlarvae may be started with *Artemia* nauplii. However, because *Artemia* is very expensive and scarce, some hatcheries use rotifers as the initial food for sea bass (Çoban, 2000).

Based on the traditional feeding protocol for sea bass larvae adopted by majority of the hatcheries, the following feeding rates are presented (Table 4).

Much progress has been devoted to meeting the nutritional requirements of marine fish larvae using cultured live food and inert replacement diets (Kolkovski, 2001). The nutritional quality of commercially available *Artemia* strains being relatively poor in eicosapentanoic acid (EPA, 20:5 n-3) and especially docosapentanoic acid (DHA, 22:6 n-3), it is necessary to enrich the live prey with emulsions of marine oils. The most commonly applied boosting technique is a 24 h enrichment period after hatching. Newly enrichment products in general contain higher rates of DHA, AA, vitamin C and vitamin E than traditional formulations (Sargent *et al*., 1999, Sorgeloos *et al*., 2001, Han *et al*., 2001).

Alternative feeding strategies developed are geared towards reduction of the use of *Artemia* and earlier replacement with microparticulate feeds. On-grown *Artemia* (48-72 h) also has potential for limiting *Artemia* cyst requirement and is cheaper.

Most hatcheries in Turkey use *Artemia* cysts at the range of 110 to 140 kg and about 30-50 kg of enrichment products containing high level of n-3 HUFA to produce 1 million fry (close to standard feeding rate) and inert diets are introduced starting on the D-20 and onward.

At Bodrum Fisheries Research Institute, *Artemia* consumption for sea bass rearing, has been reduced to 45% (traditional feeding protocol) by replacement with compound diet of 80-200 µm starting on D-17 (Table 5). After D-30, ongrown (48-72 h) *Artemia* is utilised. Survival rates obtained were similar to those obtained with traditional feeding protocol, but growth rate of larvae was poor (Table 5).

Growth and survival

At about 45 days of age fish had an average weight of 40-50 mg at rearing temperature of 17 to 19°C. Survival rates obtained at the end of this period range from 40 to 65%.

Nursery

Metamorphosed fish (40-45 mg, around 45 days old) are transferred to the weaning sector.

Table 4. Traditional feeding rates for sea bass larva.

Day	Live food		Days	İnert feed	Quantity
3-20	25-150	rotifer per larva		Particle size	
8-20	10-100	A.naupli per larva per day, enriched	17-29	80- 200 µm	5-30 g/m^3
20-30	200-400	A.Metanaupli per larva per day, enriched	28-41	150-300 µm	10-50 g/m^3
30-40	200-600	A.Metanaupli per larva per day, enriched	42-57	200-400 µm	20-150 g/m^3
40-57	600-0	A.Metanaupli, enriched			

Table 5. Feedig strategies with different rates of *Artemia* consumptions.

	Max artemia period	Artemia decrease period	Adaptation (weaning) period	Initiation of post weaning	Total artemia consumption for 1 million fry	Survival rate (%)	Individual wet weight larva (mg)
Traditioanal	30 th day	42 th day	42→57	58 th day	115 kg	35	110 mg
Inve strategy	28 th day	25% 24-29 50% 30→	30→57	58 th day	70 kg	33	45-50 mg
Bodrum- Güvercinlik implication	28 th day	30% 17-29 50% 30→	30→57	60 th day	65 kg	29.1-37.5	30-39 mg

Nursery rearing facilities

The weaning sectors are equipped with a number of bigger circular or rectangular tanks from 8 and 25 m^3 in capacity. Where environmental conditions are favorable, a simple open system water supply is sufficient for water renewal, provided that the incoming water goes through UV sterilizer. But during cold winters or poor environmental conditions, a semi-closed system is required.

Rearing parameters

Temperature is kept within 18-22 °C range. Although higher temperatures result in better growth, there is an increase in bacterial growth and fish metabolic rate, thus oxygen consumption and total ammonia nitrogen increase as well, to the detriment of the fish.

Salinity is ambient (38-40‰), but better feed conversion and survival rates is achieved using slightly brackish water (20-25 ppt).

Dissolved oxygen level in rearing water should be kept as close to saturation as possible through pure oxygen input. An 80-100% saturation measured at the water inlet is a safe range. High fish densities can be maintained only if pure oxygen is used.

Water renewal is between 50-100% of the total water volume per hour.

Photoperiod is shortened by two hours compared to what is used in the larval sector, i.e. 14 hours light and 10 hours dark. Natural photoperiod is used when the fish is 80-90 days old.

Stocking density may be kept between 15,000-20,000 fry/m^3 at the start of weaning and at the end of the nursery stage, it is most frequently 10-15 kg/m^3.

Feeding

In the traditional feeding protocol for sea bass, weaning starts at D-42 and ends on D-57 (Table 5). Feeding rate on *Artemia* in the first 4-5 days of weaning is the same, since this is an adaptation period for the larvae to the new rearing environment. From D-50, the *Artemia* ration is linearly reduced until the fish is completely weaned over to the new diet on D-58. It is important to minimize pollution and cannibalism, and for the fish to better adapt to dry feed. Thus, different practices have been developed by different hatcheries for weaning. One is the gradual weaning of the fish from *Artemia* to dry feed. After the global shortage of *Artemia*, alternative feeding protocols proposed for sea bass is based on this method but at the earlier stage. If weaning is carried out between days 30 and 57, *Artemia* consumption is around 35-40 kg less than traditional feeding strategy (Table 5).

Survival and growth rates

During the adaptation period, mortality may reach 20-25% of the fish. It largely depends on the initial weight of the larvae and feeding strategies used in this period.

Growth rate of the fish varies widely depending on temperature and food. At the end of the weaning phase (D-70 - D-80), juveniles reach 150-200 mg, however, some hatcheries reported higher individual weights up to 0.5 g at same age.

Pre-growing period

After completion of weaning to dry feeds, juveniles weigh 60-70 mg at D-60 and 150-200 mg at D-75 - D-80 at water temperatures of 17 to 18°C. Specific growth rate of 5.5%. Feed consumption of 4.5% BW with a feed conversion rate of 1.0-1.5%. Survival rate is 99.5%. Mortality rates range from 2 to 10% during this period.

Stocking density is kept between 10,000 and 15,000 fry/m^3 by addition of pure oxygen.

At the water temperatures ranging from 18 and 21°C, fry weighing 150-200 mg reach 1 g in 30 days (Büke ve Imam, 2001).

Developmental abnormalities

Morpho-anatomical abnormalities of farmed fish had impacts directly on product quality, production costs and market potential.

Despite the much higher incidence of functional swim bladders using current rearing techniques, spinal deformities of varying degrees of severity are still common among intensively-reared sea bass. Aside from spinal deformities, opercular anomalies and caudal deformities are prevalent. Most hatcheries in Turkey faced these problems at the rate of 2 to 5% of their total production.

Although individual studies have provided evidence for the specific factors of fish osteological maldevelopment, a major determining factor can not be singled out. Thus, some precautions are given which include maintenance of a clean water surface, enrichment of live prey with essential fatty acids and vitamins, avoiding rapid changes in physical water parameters and high water velocities, providing or minimizing mechanical disturbance and proper selection of broodstock to prevent inbreeding to occur.

Conclusions

Under the present rearing systems and production techniques, the 15 active hatcheries in 2001 produced around 50 million fry. Due to the decrease in sea bass fry demand and the fall in its price (from 14-17 cent to 13 cent), small-scale hatcheries have stopped operating, while large companies aim at higher target production by pouring in new investments. Thus, there will be no significant changes in sea bass fry production in the near future.

Survival and growth rates of larvae and fry have increased considerably as a result of improved feeding strategies of the breeders and in the improvement of the nutritional quality of live feed and fully controlled rearing conditions. However, more studies are still needed on larval nutrient requirements (Planas and Cunha, 1998), since the maximum capacities of lipids and HUFA for fish larvae are not yet known.

The actual cost of sea bass fry production is between 9.5 and 12 cent and the selling price is 13 cent, it is thus important to look into ways to decrease its production cost.

In most hatcheries, off-season spawning by reduced or extended photoperiod is carried out with the combination of temperature changes. This is done by cooling or heating the rearing water and showed to be an important cost-increasing factor in production. Thus, the methods totally avoid or limit energy utilizations of high importance. Present experience, fish reared at water temperatures of Bodrum environs and with constant photoperiod, advanced spawning could be obtained in the beginning of December. It is also possible to get earlier spawning by cooling the water within a short period. In northern Aegean coastal areas where water temperatures are lower than those in Bodrum during autumn and spring, off season spawning could be easily achieved.

The cost of live food production constitute 40-45% of one hatchery operation. In most hatcheries, 110 to 140 kg *Artemia* cysts and 30 to 50 kg enrichment products are used for the production of one million fry.

Commercially available larval microdiets of 80-200 μm have already been tried by fish farmers since year 2000 as replacement of *Artemia* on D-25 or older larvae as compared to the recommended age of D-17.

At Bodrum Fisheries Research Institute, approximately 45% reduction of *Artemia* utilization has been realized, compared to the standard feeding protocol. Although there was no significant differences in survival, larval growth was poor.

Some researchers (Planas and Cunha, 1998; Kolkovski *et al*., 1997) point out that the poor growth rates resulting from feeding with microdiets could not be due to a deficiency in digestive capacity (endogenous enzyme production) but rather to a deficiency in the diet in meeting the larval nutritional requirements. However, if the progress obtained in the improved microdiet production (Yufera *et al*., 1999; Cahu and Zambanino Infante, 2001; Kolkovski, 2001) is put into practice in larval rearing, *Artemia* utilization and production cost will be reduced significantly (Mayer *et al*., 1988).

Fry quality is of a great importance in hatchery operation since it affects the production cost and market competition. The rates of morphological deformities in sea bass fry (2-10%) decreased considerably with more information on the physiological development and nutritional requirements of larvae. Although there are a multitude of factors affecting fish deformities which is not fully understood, it is necessary to optimize all the rearing processes.

It is very important that research results in genetics are transferred to the production sector and that the researchers' aim on producing of fast-growing and disease-resistant juveniles will be realized.

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