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Investigation on feeding tables for sea bass (*Dicentrarchus labrax* L.,1758) in net-cage (Pinar Marine Company) culture

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SUMMARY – Although feed manufacturers provide feeding tables for marine fish according to water temperature, these should be tested under local conditions. A feeding table proposal was tested for *ad libitum* feeding of sea bass in a cage farm of Pinar Marine Company, Izmir, Turkey. Fingerlings were divided into 3 groups (1.83 g, 1.80 g and 1.87 g) and were stocked in 5×5×5 m net cages at the beginning of the experiment. They were transferred later on to 7.5×7.5×7.5 m cages, then to cages of 12 m in diameter at a depth of 10 m, and finally to 20 m diameter cages at a depth of 15 m. Fish were fed on type-2 granule feed at the beginning and on type-4 pellets (12% max. moisture, 45% min. crude protein, 12% crude oil, and 3536 kcal/kg of digestible energy) at the end of the feeding period. Fish were checked monthly, and growing rate, feed conversion rate and fish mortality were studied.

Keywords: Sea bass, feeding table, nutrition.

RESUME – *"Etude sur des tables de valeur alimentaire pour le bar (*Dicentrarchus labrax *L., 1758) cultivé en cages à filets (Pinar Marine Company)". Bien que les fabricants d'aliment fournissent des tables de valeur alimentaire pour les poissons marins en fonction de la température de l'eau, il faudra cependant les tester par rapport aux particularités des conditions locales. Une proposition de tables alimentaires a été testée en alimentation à volonté chez le bar dans une ferme de cages sur la côte d'Izmir, Turquie. Les juvéniles étaient divisés en 3 groupes (1,83 g, 1,80 g and 1,87 g) et placés dans des cages à filets de 5×5×5 m au début de l'expérience. Ensuite ils ont été transférés dans des cages de 7,5×7,5×7,5 m, puis dans des cages de 12 m de diamètre à 10 m de profondeur et finalement de 20 m de diamètre à 15 m de profondeur. L'alimentation a commencé par des granulés de type 2 et finalement des granulés de type 4 (humidité max. 12 %, protéine brute min. 45%, huiles brutes 12% et énergie digestible 3536 kcal/kg). Les poissons faisaient l'objet d'un suivi mensuel, et le taux de croissance, le taux de conversion alimentaire et la mortalité des poissons étaient étudiés.*

Mots-clés : *Bar, tables de valeur alimentaire, nutrition.*

Introduction

Total aquaculture production in the Mediterranean reached 1,349,777 tonnes in 2001, which represented approximately 3% of the world aquaculture production (48,413,635 tonnes). Although Mediterranean aquaculture used to focus more on mollusc production (62% in 1992), the share of fish production is constantly increasing (from 37% in 1992 to 53% in 2001), as it is happening at a worldwide level (Basurco and Lovatelli, 2003). Regarding sea bass culture in Mediterranean countries, there is an increasing trend, as shown in Table 1.

Fisheries production for Turkey was around 582,000 mt in 2000. The main part of this production comes from marine fish fishing. Marine fish and freshwater fish culture produce around 79,000 mt. Marine fish culture is also very important in Turkey (Table 2).

According to Hoşsu and Korkut (1996a,b), the aquaculture and fish feed manufacturing sector of Turkey is improving over time. Aquaculture has to be organized as an integrated sector from feed manufacturer to farmer and this would enhance conditions to improve quality and health.

Table 1. Sea bass production in Mediterranean countries (tons) (source: FAO, 2003)

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Croatia	-	383	174	182	247	172	394	1152	1300	1300	1520	1800
Cyprus	15	19	34	20	99	100	57	205	298	299	383	422
Egypt	720	720	720	720	755	977	2238	3612	2725	10,031	841	1239
France	414	550	1330	2138	2656	1997	2114	3100	3225	3020	2721	2746
Greece	2530	5043	7345	6870	9539	11,662	15,193	18,469	24,413	26,653	25,342	23,860
Israel	-	-	100	300	700	66	-	30	26	150	214	346
Italy	1538	1826	2466	2850	3600	3800	4600	5850	7200	8100	9500	7176
Malta	150	350	400	350	350	621	720	80	80	234	196	50
Morocco	96	119	193	332	533	407	568	563	365	250	202	325
Slovenia	-	6	13	34	29	53	29	54	35	46	59	25
Spain	92	143	370	351	461	693	511	936	1227	1837	2307	3338
Tunisia	305	161	419	571	230	210	565	551	254	202	461	649
Turkey	777	808	3158	2229	2773	5210	6300	8660	12,000	17,877	15,546	14,339
Total	6637	10,128	16,722	16,947	21,972	25,968	33,289	43,262	53,148	69,999	59,292	56,315

Table 2. Fisheries production of Turkey (DIE, 2000)

Year 2000	
Fishing	
Marine fish	441,690 t
Freshwater fish	42,824 t
Other products	18,831 t
Aquaculture	
Freshwater fish	43,385 t
Marine fish	35,646 t
Total	582,376 t

It is difficult to study the culture of living organisms in natural conditions. Sea net cage culture is one such condition. Very important points to be considered are species of the organism and culture conditions of the facilities. After the selection of the species, the cage site has a direct effect on the success of the farm. Caution is necessary because after installation there are no more chances to interfere with natural events. Management of the cage, feeding and other duties follow.

Aquaculture is based on feeding fish appropriately in adequate conditions. Quality of raw material of feed, feed manufacturing system and feeding are important steps for a successful nutrition and feeding of fish. The first two steps are the feed production period and the last step is the feeding period. Even if high quality is achieved in the first two steps, inappropriate feeding would be a great handicap to the success of the farm.

Fish feeding is generally organized according to the water conditions and temperature. El-Sayed and El-Ghobashy (1993) determined that feed efficiency, growth rate and survival rate would be decreased by increasing the stock density of sea bass cage culture. Environmental conditions and feeding regime is mostly effective on growth in this case.

Productivity can be improved and a large part of the farm's expenses can be saved through adequate feeding. The feeding table plays an important role in this case.

Feed manufacturers are preparing proposals for fish feeding programmes according to water temperature and fish size. Actually, the farm and the cages could be changed from sites in protected bays to offshore; also bay currents, dominant winds, depth of the water, and feeding methods could

have an effect on aquaculture conditions. That is why feed manufacturers have to monitor the farms to which they have sold their feed. They can choose representative farms for the area and monitor the growing of fish throughout the whole season. This should be one of the technical tasks of the feed manufacturer. Preparing feeding tables according to these studies would be more beneficial for the farmers. At the same time these studies would show the success of the manufacturer's feed production quality. Besides, interaction between feeding and environment is another perspective of this job.

Material and methods

Material

Based on a specific feeding table for each farm, this case study has been planned by one of the feed manufacturers in Izmir and a fish farm in Izmir-Cesme (Fig. 1). Study is planned for the whole season and a 7.5 month period of the programme is provided below.

Fig. 1. Map of the research area.

Fish came from the same batch, which hatched on 6th May 2001. These fish were divided into 3 groups according to size and transfer time to net cages. These 3 groups of fish were then separated into two groups according to the feeding method and placed first in 5×5×5 m PE cages and later transferred to 7.5×7.5×7.5 m HDPE square cages for the ongrowing period to obtain a lower stock density and better growth (Figs 2 and 3).

Fig. 2. View of 5×5×5 m net cages.

Fig. 3. View of 7.5×7.5×7.5 m net cages.

Feeding began by granule feed and then continued with pellets No. 3 and 4. Nutritional composition of feed is given in Table 3.

Table 3. Nutritional composition of feed

Feed type	Crude protein %	Crude oil %	DE (Kcal/kg)
Granule feed (2)	50-52	17-20	3900
Granule feed (3-4)	48-50	15-18	3800
Pellet 3	45	10	3536
Pellet 4	45	10	3536

Method

Fish groups were formed according to the date they were transferred to the cages and were named as A, B and C. Each group was divided into two parts according to their feeding methods (Table 4).

Table 4. Feeding method, stock density and average initial fish weight at time of transfer to net cages

Groups	Feeding method	Transfer date	No. of individuals	Average weight (g)
A_1	From feeding table	16-08-2001	97,831	1.86
A_2	*Ad libitum*	16-08-2001	88,586	1.83
B_1	From feeding table	21-08-2001	90,901	1.75
B_2	*Ad libitum*	21-08-2001	97,300	1.80
C_1	From feeding table	23-08-2001	90,002	1.47
C_2	*Ad libitum*	23-08-2001	89,489	1.40

As seen in Table 4 the live weight of group A was around 1.84 g, group B was around 1.77 g and group C was 1.44 g. Even if all the fish came from the same batch, live weight could be changed for many reasons. So their transfer time to the cages has changed because of their live weight.

The feeding rate of Groups A_1, B_1 and C_1 has been determined according to the feeding table that feed manufacturers give to farmers (Table 5).

Table 5. Proposal of feeding table of feed manufacturer (feeding rate, %)

Fish weight (g)	Feed type	Water temperature (°C)							
		12	14	16	18	20	22	24	26
2-9	Granule 1	1.0	1.4	1.8	2.2	2.7	3.2	3.9	3.5
9-15	Granule (2.4)	0.8	1.2	1.5	1.8	2.2	2.5	2.9	2.5
15-35	Pellet 2	1.0	1.1	1.4	1.8	2.0	2.3	2.2	2.0
35-80	Pellet 3	1.0	1.1	1.4	1.5	2.0	2.3	2.2	2.0
80-150	Pellet 4	0.8	1.1	1.1	1.2	1.3	1.5	1.3	1.5

Studies began in August 2001 and 7.5 months of this study are provided (to April 2002). Total length and weight of fish were measured monthly by random sampling. Water temperature and feed consumption were recorded daily.

Feed conversion rate (FCR) and specific growth rate (SGR) were calculated as shown below:

$$FCR = \frac{\sum \text{Feed consumption}}{\sum \text{Live weight}} \times 100$$

$$SGR = \frac{\text{Ln } W_2 - \text{Ln } W_1}{t_2 - t_1} \times 100$$

W_1 = Initial weight; W_2 = Final weight; t_1 = Initial time (day); t_2 = Final time (day).

Results were evaluated statistically.

Results

Water temperature

As mentioned before, the present study began in August 2001 and water temperature was taken each day. These measurements are given in Table 6. The lowest average temperature was 12.4°C and was observed in January and the highest was 23.5°C in August.

Table 6. Water temperature (^{o}C)

Temperature	August	September	November	January	April
Maximum	25	23.6	20.5	13.2	19.5
Average	23.5	22	19	12.4	18
Minimum	21.7	21.3	17.3	10.6	16

Hidalgo *et al*. (1987) have investigated the effects of water temperature on feed efficiency of sea bass (20-30 g). One month of feeding rate observations has resulted in 1.2% of live weight at 15-20°C temperature and 1.7% at more than 20°C.

Hidalgo and Alliot (1988) have studied the effects of water temperature on protein utilization and requirements in juvenile sea bass. They have seen optimum protein utilization and growth between 15°C and 20°C. They recommended 50% of crude protein in feeding these fish in this period.

Fish growth

Fish growth is given in Table 7. Biometric growth performance is prepared according to these numbers (Figs 4 and 5).

Table 7. Average of monthly measurements

Groups	August		September		November		January		April	
	TL†	W†	TL	W	TL	W	TL	W	TL	W
A_1	7.37	4.83	10.25	13.86	13.68	29.8	16.5	43.4	21.9	125.6
± (SD)	0.10	0.19	0.15	0.61	0.40	0.10	0.09	0.34	0.32	5.78
A_2	7.13	4.66	9.12	9.86	14.96	32.6	18.6	52.3	22.7	135.9
± (SD)	0.07	0.21	0.13	0.41	0.31	0.50	0.15	0.69	0.31	6.04
B_1	7.20	4.60	9.73	12.0	11.6	18.9	14.8	38.7	21.1	108.5
± (SD)	0.11	0.22	0.14	0.55	0.25	0.41	0.31	0.52	0.25	4.35
B_2	7.30	4.00	8.57	8.37	11.9	19.5	15.6	41.6	21.3	113.8
± (SD)	0.06	0.17	0.12	0.35	0.47	0.19	0.75	2.37	0.18	1.13
C_1	5.59	2.05	8.02	8.20	10.9	16.1	13.0	32.2	18.9	90.5
± (SD)	0.04	0.12	0.10	0.30	0.15	0.25	0.23	0.86	0.24	1.89
C_2	5.76	2.54	8.05	7.51	11.8	17.6	13.9	99.9	19.7	92.6
± (SD)	0.04	0.10	0.08	0.33	0.25	0.14	0.21	0.55	0.31	1.59

†TL: Fish total length (cm); W: Fish live weight (g).

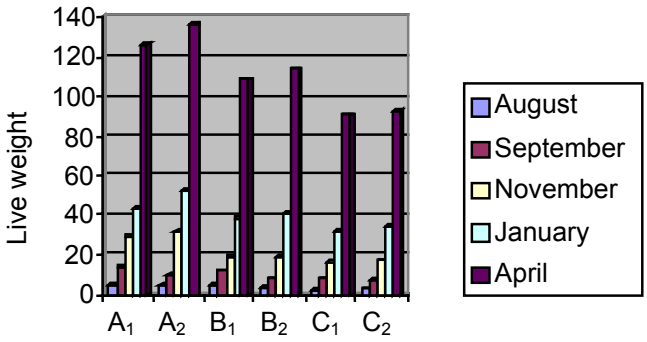

Fig. 4. Fish growth performance.

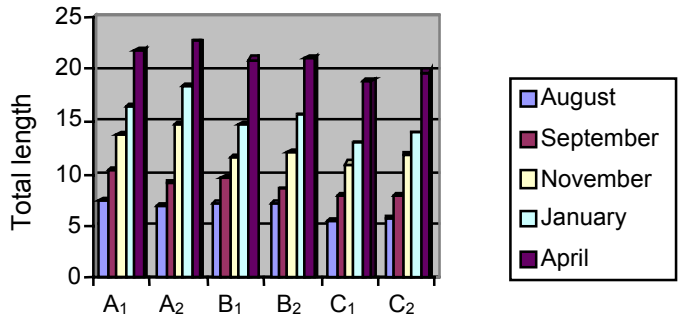

Fig. 5. Total fish length performance.

As a result of measurements of 5 samples, fish growth performance has been improved by increasing water temperature.

Hoşsucu *et al.* (1991) have studied growth of sea bass similarly in 5x5x5 m net cages in Bodrum (Turkey). Fish reached 138.30±0.69 g in 190 days from 36.15±0.05 g. and 178± 7.99 g in 10 months and 444.4±29.2 g in 15 months.

Specific growth rate

The specific growth rate gives periodical growth of the fish. As the present study represents a certain period of the whole study this calculation method is used and results are given in Table 8.

Table 8. Specific fish growth rate

Groups	Number of days	SGR %
A_1	227	1.435
A_2	227	1.485
B_1	222	1.423
B_2	222	1.535
C_1	220	1.737
C_2	220	1.649

These results are meaningful, because SGR is expected to be around 1.5% in short periods. The present study lasted 7.5 months and SGR of group C is shown as more than 1.5% because of the low initial weight and good feed conversion ratio of these fish. So all groups have shown acceptable results.

Feed conversion ratio

Feed conversion ratio is one of the most important criteria in this type of studies. Decreasing FCR is shown to be successful in this study. Results of the present study are shown in Table 9.

In the present study *ad libitum* feeding provides lower FCR in group A_2 and B_2 but higher in group C_2. This might be due to the low initial weight of group C. When this result is checked by SGR, numbers are acceptable.

Table 9. Feed conversion ratio

Groups	August	September	November	January	April	Average
A_1	-	1.43	1.84	2.27	0.72	1.57
A_2	-	1.72	1.22	1.89	0.83	1.42
B_1	-	1.43	3. 01	1.17	0.74	1.59
B_2	-	1.71	1.70	1.19	0.79	1.35
C_1	-	1.11	2.02	1.27	0.74	1.29
C_2	-	1.48	1.77	1.42	0.79	1.37

Mortality

A significant amount of mortality has not been observed in this study (Table 10).

Fish mortality was higher in group C than the others. This result may be related to their lower weight in January. Decreasing water temperature could not be accepted easily by this group in this month.

Table 10. Fish mortality (%)

Groups	October	January	April	Average
A_1	2.16	3.23	0.6	1.99
A_2	1.08	0.77	0.9	0.93
B_1	2.12	1.49	0.77	1.46
B_2	2.04	1.82	0.95	1.60
C_1	2.73	4.13	1.14	2.67
C_2	2.47	5.77	0.49	2.91

Conclusion

Studies are planned from hatchery to harvest. In the present study a 7.5 month period is discussed.

Temelli *et al.* (1992) fed 30-35 g sea bass 1%, 1.4% and 1.8% of their live weight for 4 months. The best results have been observed at 1.8 % feeding rate at 15±2°C.

Korkut (1992) has studied sea bass from 4.13±0.14 g initial weight to harvesting period at 5x5x5 m net cages in Bodrum (Turkey). Fish reached 628.45±34.815 g in 20 months. Temperature range was 12.6-26.1°C and FCR was 2.43.

Assembling the results of growth rate, the fish in the present study were acceptable. Final weight of groups is shown in Table 11.

Table 11. Final average weight of fish

Group	Weight (g)
A_1	125.6
A_2	135.9
B_1	108.5
B_2	113.7
C_1	90.5
C_2	92.6

Also feeding rates show that there could be differences by *ad libitum* feeding (Table 12).

Table 12. Feeding rate in present study

Group	Feeding rate %				
	August 23.5°C	September 22°C	November 19°C	January 12.4°C	April 18°C
A_1	3.5	2.5	1.9	1	1.2
A_2	2.9	2.4	2.1	1	1.3
B_1	3.5	2.5	1.9	1	1.2
B_2	3.2	2.5	2.1	1	1.3
C_1	3.5	2.5	1.9	1	1.2
C_2	3	3	2	1	1.3

Comparing the two feeding methods, fish feeding rate of fish decreased in the *ad libitum* method in August, while water temperature was around 23.5°C. In September, feeding rate from the table and *ad libitum* methods are similar in groups A and B but a higher rate of feeding is observed at *ad libitum* feeding in group C from November to April. Results have shown that there could be differences in the feeding table by checking *ad libitum* feeding for each farm.

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