Important factors affecting trout production in the Black Sea Region, Turkey

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ABSRACT: We determined the factors affecting trout production in the Black Sea Region, Turkey, on 55 trout farms. The factors affecting trout production were studied using the Cobb-Douglas production function. The explanatory variables in the model explained 99.4% of the variation in trout production. The partial percentage of the feed-use variable was 99%, whereas that of all other variables was 1%. The education level of operators, feed use and capital use positively affected trout production, whereas the stocking density and pond size negatively affected trout production. Technical assistance and extension programs concerning stocking, feeding and disease control that resulted in decreased stocking density and increased feeding efficiency may increase trout production by approximately 20%.

Keywords: aquaculture; Black Sea Region; Cobb-Douglas model; production function; trout

The importance of aquaculture is gradually increasing worldwide. According to the Food and Agriculture Organization (FAO) statistics, the world aquaculture production has increased from 11 to 41.9 million tons in the last two decades (FAO, 2007). The aquaculture growth can play a major role in improving food security and can diversify economic opportunities at both the local and national level in developing countries. Increased employment in aquaculture can help to reduce migration and maintain the quality of life for the rural population (Burbridge et al., 2001).

Turkey has many favourable sites for aquaculture. The aquaculture production increased 4.9% annually, on average, between 1994 and 2004; that is more than the growth rates of both the population and red meat production. Aquaculture accounted for 14.6% of the total fisheries production and contributed 25% of the total value added of fisheries. For many years, the aquaculture sector has been dominated by freshwater trout farming. In Turkey, inland aquaculture constitutes 47% of the total aquaculture production (ABGS, 2006). Rainbow trout (*Oncorhynchus mykiss*) is the main freshwater species raised in Turkey. Whereas 990 tons were produced in 1986, production reached 45.082 tons in 2004 (MARA, 2007). Thus, Turkey has become one of the top trout-producing countries in Europe. The Black Sea Region contributed approximately 12% of total aquaculture production in Turkey.

Despite the rapid development of trout production in Turkey, trout farmers often have inadequate information about the marginal impact of factors affecting production. This results in Turkish trout farmers failing to fully exploit technology by making inefficient decisions. Therefore, policy makers have focused on the economics of trout production in Turkey. However, farm-level information on input-output relationships in trout production is unsatisfactory.

Previously, a great deal of empirical work was conducted to reveal the economics of trout production (Byron, 1982; FAO, 1990; Klontz, 1991; Johnston and Logan, 1992; Johnson and Walsh, 1998; Nepal et al., 2002; Lever et al., 2004). However, few studies have addressed the issue of production optimization in trout aquaculture (Vehaen, 1995; Hayvärinen, 2004; Varvarigos, 2004; Campbell et al., 2006). Very limited studies have been conducted to optimize production using quantitative models. Therefore, our objectives were to estimate a production function for trout farms in the Black Sea Region, to identify important factors affecting trout production, and to create strategy for trout farms based on the determinants of trout production.

MATERIAL AND METHODS

This study was conducted in the Black Sea Region, which is located in northern Turkey. Trout farming occurs mainly in ponds. The research area covered 10 provinces in which trout farming is the most common: Samsun, Ordu, Trabzon, Rize, Sinop, Artvin, Düzce, Giresun, Bolu, and Kastamonu. Farms in this region constitute 87% of the total physical capacity and 86% of all the aquaculture farms.

A quantitative model was developed to determine the factors affecting trout production, assuming there was a perfectly competitive market structure. Trout production was used as the dependent variable. Five inputs, i.e. feed use, capital use, pond size, stocking density, and education level of operators, were included in estimating the production function.

The results of a likelihood ratio-type test that was used to test the Cobb-Douglas model against the translog showed that Cobb-Douglas was an appropriate model for the data available. Thus, we used the following model:

$$lnTP = ln\beta_1 + \beta_2 lnFU + \beta_3 lnTCU + \beta_4 lnTPS + \beta_5 lnSD + \beta_5 lnELO + u_i$$

where:

TP = trout production (kg)
FU = feed use (kg/year)
TCU = total capital use (€)
TPS = total pond size (m^3)
SD = stocking density (fish/m^3)
ELO = education level of operators (year)
u_i = a stochastic error term
All β's = unknown parameters

Marginal products of the explanatory variables were calculated using Eq. 1 (Doll and Orazem, 1978; Gujarati, 1995; Thirtle, 1996). Production function parameters were estimated using the ordinary least-squares (OLS) method in SPSS 12.0.

$$MP_{xi} = \frac{\delta Y}{\delta X_i} = \beta_i \frac{\bar{Y}}{\bar{X}_i}$$

The bulk of the data used in this study was collected from 55 randomly selected trout farms in the Black Sea Region. Farm data were gathered through a questionnaire. Randomly selected farmers were interviewed to obtain resource use and production data for the 2000–2001 production period.

The variable of the education level of an operator included in the model tested the hypothesis that more educated farmers had better trout production. Schooling of farmers (years) was a proxy variable, and 5, 8, 11, and 15 reflect graduation from primary school, secondary school, college and university, respectively. Capital was measured as an aggregate value of cash expenditures on feed, harvesting, and marketing. To study the pond use efficiency, the variables of pond size and stocking density were included. The variable of feed use was included to determine the feed conversion ability of farms.

The exogenous variables included in the analysis can be divided into three groups: personal characteristics of farmers (experience, which reflects the years spent working in aquaculture), farm characteristics (number of ponds on the farm, water flow rate for trout production (l/s), feed conversion ratio (%), trout production (kg)), and marketing information (marketing size of trout (g), distance to market (km), wholesale and retail fish price (€/kg) and price of cooked fish (€/kg)).

RESULTS AND DISCUSSION

In the Black Sea Region, about 76% of farms were family owned. Farmers generally established their farms using their own equity. The equity ratio was about 92%. On average, farmers obtained 53% of their total income from aquaculture. Less than a half of the farms kept records of farm activities. Because only 7.3% of farms employed a technical person, fish disease and death were common. Insurance companies are not willing to insure fish because of the high risk involved in trout production. Approximately 21.8% of farmers insured their ponds and respective buildings. Approximately one-third of farms had troubles with water sufficiency. Approximately 44% of farms did not measure any water parameters. Water pollution affected 38.2% of farms. Regarding the sources of the stock, two thirds of farms used their own eggs for trout production. Growing in raceways lasted 13.72 months on average (range 12–14 months).

Table 1. Exogenous variables for the trout farms

Variable	Minimum	Maximum	Average	Standard deviation
Personal characteristics of farmers				
Operator's experience (year)	1.00	26.00	7.56	5.626
Farm characteristics				
Number of ponds on farm	1.00	134.00	20.04	22.916
Flow rate of water supply for trout production (l/s)	5.00	800.00	103.75	170.275
Feed conversion ratio (%)	1.00	2.00	1.45	0.168
Trout production (ton)	1.000	100.000	14.863	22.577
Marketing information				
Market size of trout (g)	150.00	310.00	210.00	32.935
Distance to market (km)	1.00	100.00	34.53	31.49
Fish wholesale price (€/kg)	0.99	2.44	1.61	0.30
Fish retail price (€/kg)	1.28	2.42	1.84	0.29
Fish price in restaurants (€/kg)	1.26	3.86	2.51	0.81

Although the physical capacity was 26.5 tons per annum, only 55.4% of the capacity was used. In general, trout farmers used typical commercial pellet feed which contains 35–45% protein and 10–15% fat. Unconscious feeding was also common in the farms. Farmers' participation in extension courses was very low.

Other basic characteristics of the trout farms are presented in Table 1. It is evident from these statistics that trout farms are small in terms of output and pond size. The sampled trout farms averaged 19 ponds per farm. The most common rearing system used on sampled trout farms was concrete raceways, with the exception of some larger farms that had modern circular concrete tanks. The sampled trout farms, on average, had ponds approximately 1 200 m^3 in total volume. The average total asset of the farms was € 44 000. The farms used approximately 18 tons of feed and produced about 15 000 tons of trout. The range of farm operators' experience in trout production was vast, whereas their education level was moderate. The average stocking density was 72 fish per m^3. Most of the trout farms bought fingerlings from fingerling producers.

The average feed conversion ratio was 1.45. Marketing activities were intensive in spring and summer. Trout were harvested daily and marketed directly to local restaurants, hotels, and factory catering services as a fresh product. Some farms (49%) had their own restaurants on or close to the farm. The average distance to a market was 35 km. Farmers sold their fish when they reached approximately 213 g. When the average wholesale price per kilogram was € 1.61, the retail price per kilogram reached € 1.84. However, trout was sold cooked for € 2.51 in restaurants. The average selling price per kilogram was approximately € 2.01 in July and € 1.24 in January, whereas the average price per fingerling was € 0.004.

For the parameters of the production model, the signs of the coefficients of the production function were as expected (Table 2). The trout production model was statistically significant at the 1% level. The adjusted R^2 of the model indicated that 99.4% of the variation in trout production was explained by the explanatory variables. The partial percentage of the feed use variable was 99%. The contribution of capital use, stocking density, pond size, and education level of operators was 0.30%, 0.26%, 0.22%, and 0.22%, respectively. The coefficients for the education level of operators, feed use, and capital use confirmed the expected positive relationships between the education level, feed use, capital use, and total trout production. Stocking density and pond size had negative coefficients. The estimated elasticity for the education level of operators, feed use, capital use, stocking density and pond size were 0.06, 1.06, 0.04, –0.13, and –0.09, respectively ($P < 0.05$), indicating decreasing returns to scale. Restricted least-squares regression was used to formally test the null hypothesis of a constant return to scale. The calculated F statistic was 7.46, which exceed the critical F value of 3.74 at the 1%

Table 2. Variables included in the production function, and parameters estimated by ordinary least-squares regression

Variable	Descriptive statistics		Parameter estimates			
	mean	standard deviation	b_i	S_b	t	Slope $b_i \frac{\overline{Y}}{\overline{X}}$
Constant			–0.159	0.154	–1.031	
Feed use (kg/year)	18 069.00	26 716.00	1.064***	0.027	38.930	0.875
Total capital use (€/year)	44 113.17	67 424.55	0.041**	0.017	2.340	0.008
Total pond size on farm (m^3)	1 186.00	1 512.00	–0.090***	0.027	–3.280	–1.128
Stocking density (fish/m^3)	72.00	28.00	–0.131***	0.034	–3.840	–27.042
Operator's education level (years)	3.46	2.06	0.060**	0.028	2.130	297.260

*,**,***Significance at the 10, 5, or 1% level, respectively

significance level. Therefore, the null hypothesis of a constant return to scale was rejected. Feed use and stocking density showed the greatest elasticity. Based on the results, these two inputs had major effects on trout production (Table 2).

The model predicted that when other explanatory variables are held constant, a 10% increase in feed use would increase trout production by 10.6%. In other words, if the feed use increased by 1 kg, trout production should increase by 0.88 kg. Based on this coefficient, it is clear that the sampled trout farms were inefficient in terms of the feed use. The main reasons for this inefficiency were unconscious feeding, the relatively high cost of feed, and high temperatures in summer. The survey showed that 61.8% of the sampled farms ignored basic parameters such as water temperature, fish age, stocking rate, and climate conditions when deciding on the quantity of feed to supply to the fish. Farmers preferred to consider only fish weight or water temperature. However, parameters such as fish age, stocking density, climate conditions, and feed prices should be considered simultaneously to obtain reasonable production results (Shang, 1981).

The coefficient for the education level suggests that farms managed by more educated operators produce much more trout than those managed by less educated operators. Low education levels resulted in unconscious feeding and capital use leading to production losses. Less educated farmers also had relatively less contact with information sources. Trout farm operators contacted extension services twice per year on average. Participation in training programs was also low because of the distance to education services and insufficient training programs. Only 63% of all farm operators had participated in at least one training program. The education level finding was compatible with the coefficient for the capital use. The elasticity of the variable of capital use indicated that with a 10% increase in total capital use, trout production should increase by 10.4%. It is clear from the above evidence that the additional capital use is not profitable for farms because of the high opportunity cost.

Our model estimation revealed that stocking density and pond size negatively affect trout production. With a 10% decrease in stocking density, trout production should increase by 13.1%. This coefficient indicates that the current stocking density was higher than the optimum stocking density. In contrast, the pond size variable indicates that larger farms could use their physical capacity more efficiently than smaller ones. A 10% decrease in the pond size should increase trout production by 9%. In the Black Sea Region, there was a negative relationship between the capacity use ratio and pond size. Based on the curve estimation results, the capacity use ratio should decrease by 1% when the pond size is increased by 10 m^3 (Figure 1).

CONCLUSIONS

We examined the factors that affect trout production on pond-based commercial trout farms in the Black Sea Region of Turkey by estimating a production function. The education level of operators, feed use, and capital use positively affected trout production, whereas the stocking density and pond size

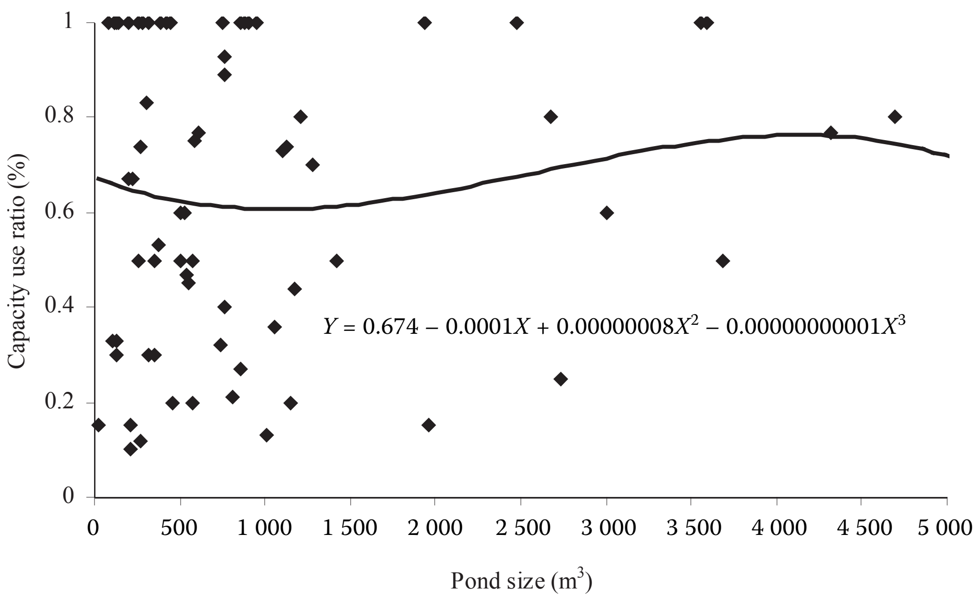

Figure 1. Relationship between the pond size and capacity use ratio

negatively affected trout production. Additionally, the trout farms had decreasing returns to scale.

Based on the production function results, feed use and stocking density had major impacts on trout production. It is clear that the trout farms were inefficient in terms of feed and capital use. They also stocked more than the optimum level of fish, and their production size was far from optimal. In the light of these results, substantial decreases in inputs or gains in outputs could be attained by using the existing technology on these trout farms. The policy implications are clear. Policy makers should focus on enhancing farmers' access to information via the provision of better extension services and farmer training programs, and raising the education level of farmers to increase trout production.

Farmer training and extension programs should be provided in the Black Sea Region to improve the production efficiency of individual farms. Demiryürek (2000) noted a positive correlation between production efficiency and the total information score that reflects the extent of contact with relevant information sources. Farmers who switch to more efficient production methods (e.g. changing the production function, using a new technology) more extensively seek out and contact information sources such as extension officers, research staff, and other private advisers.

Farmer training and extension activities are relatively low-cost methods of increasing the production efficiency (Ellis, 1993). However, production increases are strongly dependent upon the effectiveness of presentations made by research and extension organizations. Hence, programs should focus on human resource development and be directed to peer-leader farmers open to transforming their farms to be more market oriented. Focusing on management, input use, cooperation among farmers and, marketing efficiency in farmer training and extension programs may also help to increase trout production.

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