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Araştırma Notu / Short Note

Some Growth Parameters on European Eel (***Anguilla anguilla*** L.**,** 1758) Fed with Different Feeds

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Özet: ***Farklı yemlerle beslenen avrupa yılanbalığı (***Anguilla anguilla ***L.)'nda bazı büyüme parametreleri.*** Bu çalışmanın amacı, balıkhane artıkları (BA), tavuk kesimhanesinin bazı artıkları (TA), kuru karma alabalık yemi (YY), balıkhane artıkları ile kuru karma alabalık yemi karışımı (BA+YY) ve tavuk kesimhanesinin bazı artıkları ile kuru karma alabalık yemi karışımının (TA+YY) Avrupa yılanbalığının bazı büyüme parametreleri üzerine etkisinin belirlenmesidir. Başlangıç ortalama ağırlığı 99,07±2,96g olan yılanbalıkları 80 günlük deneme süresi sonunda en iyi TA+YY yemi ile büyüme kaydetmiştir (128,56±1,75g). Bu grubun spesifik büyüme oranı % 0,33±0,02, yem değerlendirme oranı ise 8,82±0,29 olarak bulunmuştur. Bu grubu TA, BA+YY, YY, BA grupları izlemiştir. Canlı ağırlık ortalamaları gruplar arasında istatistiki olarak farklılık göstermiştir. BA grubunun sonuç ağırlık ortalaması taze balık eti verilen yılanbalıkları için bildirilen değerler arasındadır. Gruplarda görülen ölüm oranları %7,40±4,90 ile %16,66±3,21 arasında değişim göstermiştir.

Anahtar Kelimeler: *Anguilla anguilla*, yem, ağrılık kazancı, spesifik büyüme oranı, yem çevirim oranı.

Abstract:The present study was carried out to determine some growth parameters of European eel, *Anguilla anguilla* (L) fed with different feeds; wastes of fish markets (BA), some wastes of slaughterhouses (TA), artificial trout feed (YY), mixtures of artificial feed with either wastes of fish markets (BA+YY), some wastes slaughterhouses (TA+YY). The results obtained at the end of a 80 day- study time demonstrated that the eel with initial mean weight 99.02±2.96g grew best (128.56±1.75g) on TA+YY feed. The mean specific growth and the feed conversion rates for this group were 0.33±0.02 % and 8.82±0.29, respectively. Based on all criteria applied during the course of this study, the best growth performance group TA+YY was followed by TA, BA+YY, YY, and BA respectively. There were significant differences (P<0.05) on mean body weight of the experimental groups that were tested during the present study. Final body weight value obtained for group BA is among the values reported for European eel fed with fresh fish flesh in previous studies. Mortality varied between 7.40±4.90 % and 16.66±3.21 % among all the groups.

Key Words: *Anguilla anguilla,* feed, weight gain, spesifik growth rate, feed conversion ratio.

Introduction

Eel is among very important fishes for aquaculture. As a matter of fact, it is the most common cultured fish after trout and carp. Eel culture has been carried out extensively or intensively in some countries such as Japan, China. Eel culture had started with Japanese eel (*Anguilla japonica*) for over a century in Far East, and then American eel (*A. rostrata)* and European eel (A. *anguilla)* culture were added to aquaculture species with an increasing interest. European eel of them, whose extensive culture had begun in about last 15 years in Europe, requires water temperature between 18- 30º C for optimal growth. European eel is found in seas surrounding Turkey and especially in the rivers flowing into Marmora Sea, Mediterranean Sea and Aegean Sea and also in the lakes related these seas (Aras *et al*., 2000; Güven *et al*., 2001).

Although water temperature and other properties of many reservoirs in Turkey are suitable for European eel culture, very few studies have been carried out about its culture and, furthermore eel culture has not yet been practiced. Therefore, to carry out studies to evaluate the optimal culture conditions for Turkey will be very beneficial by the means of adding the European eel into cultured fish species list in our country (Çelikkale *et al*., 1999).

As it was mentioned in a great number of scientific reports, feed and feeding are among crucial subjects in aquaculture. It is a common consensus among the scientists that the feed material should supply good and healthy growth and economical development for fish. Many researches were performed and reported on these subjects for eel. Different feeds were used according to existing possibilities and development of the fish culture and feed industry. The most widespread feed used for eel has been whole fish with no economic importance, fish offal, flesh of mussel, oysters and scallop. Beside these; silk cocoon, slaughterhouse wastes and even in some countries, duct flesh have also been utilized as feed for eel. In addition to these natural resources, artificial feed increased lipid rate also has been used. However, it has been acknowledged that the artificial feed, which was made specifically for eel in Far East, was supplemented with some discard fishes as a complementary nourishing material (Güven *et al*., 2001). The researches of Kastelein (1983), Knights (1983), Schmitz *et al*. (1984), Dosoretz and Degani (1987), Gallagher and Degani (1988), De la Higuera *et al*. (1989), Garcia- Gallego *et al*. (1994), Baştürk *et al*. (2003),

Luzzana *et al*. (2003) were conducted to determine the optimal conditions for feeding and feed ration of eel. Knights

Feed expenditure constitutes 30-70% of total expenditure in fish culture (Atay and Tatar, 1980; Yıldırım *et al*., 1999). For this reason different methods have been essayed to gain benefit from every kind of feed source nowadays especially in the countries with developed aquaculture sector (Yıldırım *et al*., 1999). The overall goal of the aquaculture industry is to decrease the feed expenditure and culture the fish species with economically more affordable costs. Yıldırım *et al*. (1999) reported that the using fish offal and wastes as feed is an economical application if the farm is close to the fish markets. Fred and Bisplinghoff (2000) stated that poultry by- product meal from rendering products could also meet the criterion demanded to produce superior quality aquaculture diets and it can be used safely in rates of 10-25% instead of fish meal or other sources having high protein quality and rates.

Some wastes from white and red meat sectors have generally been tried to be made profitable as feed with rendering products in our country. However the fisheries sector has discharged the dense organic materials as solid waste (Halkman *et al*., 2000). This situation causes organic losses along with pollution causing economic casualties in our country. Therefore, this research was carried out to determine the effects of wastes obtained from fish markets and slaughterhouses as well as artificial trout feed and the mixtures of these two sources on some growth parameters of European eel, which has not yet been cultured in Turkey.

Materials and Methods

European eel *A. anguilla* was used as fish material in this study. The fish was caught from irrigation channel in Karatas - Adana. Initial mean weight of eel was 99.07±2.96g. Research was carried out in total 15 concrete ponds with sizes of 3x3x0.6m, which were located at the local branch of General Directorate of State Hydraulic Works (DSI). Experiments were conducted in three replicates and lasted over an 80-day period between May and July. Fish was stocked at rate of 3 fish /m^2 (Güven *et al*., 2001). Water flow rate was 7l/min to each pond. The surfaces of the ponds were shaded with strafes in order to supply the hiding places for the fish.

During the study, five types feed materials; wastes of fish markets (BA) and some wastes of slaughterhouses (TA), artificial trout feed (YY), mixtures of artificial feed with either wastes of fish markets (BA+YY) and some wastes slaughterhouses (TA+YY) respectively were used to feed the fish. BA and TA were minced, and then some of them were mixed to prepare BA+YY and TA+YY by adding dry feed (at rate of 1:1). YY were prepared by adding oil (corn oil at the rate of 5% of feed) and water (at the rate of 70% of feed) to trout ground feed until it became a uniformly mixed paste (Güven *et al*., 2001). The feeds were analyzed in Research Institute of Food Science and Technology of Gebze for crude lipid (Soxet System HT 1043 Extraction Unit Tecator, AB, Sweden), calcium (Anon, 1999), crude protein and phosphorus (AOAC, 1995); in Processing Laboratory of Fisheries Faculty of Cukurova University for dry matter (Ludorf and Mayer, 1973) and crude ash (AOAC, 1984). Nourishment values of the feeds are as listed in Table 1.

Feeds were given to the fish in rate of 3% of body weight. Amount of the daily feed was divided into two parts and then stored separately in the deep freezer. Fish was fed two times in a day, once in the morning and once in the late afternoon (Güven *et al*., 2001). Water temperature and dissolved oxygen were measured daily but pH was measured once in every three days using Toledo mark oxygenmeter and pHmeter. Water temperature values were between mean minimum 24.81±1.15°C and maximum 29± 1.90°C; dissolved oxygen values were between mean minimum 5.98±1.02mg/l and maximum 6.30±1.82mg/l; pH values were minimum 6.13±0.50 and maximum 6.95±0.73 during the course of these experiments. Bottoms of the ponds were siphoned and cleaned at 3 or 4 day intervals.

Fish was randomly sampled once every 20 days. In measurements, fish body weights were taken (±0.01g) under anesthetic.

Growth performance of the fish besides mean final fish weight (g) was determined in terms of weight gain (WG), daily growth rate (g) (DGR), feed conversion ratio (FCR) and specific growth rate (SGR). These growth responses and mortality (M) of the fish in each treatment group were calculated according to formula showed below.

$$DGR = \frac{W2 - W1}{t} \qquad FCR = \frac{AF}{(W2 + WDF) - W1}$$

$$SRG = \frac{\ln W2 - \ln W1}{t} x100 \qquad WG = \frac{W2 - W1}{W1} x100$$

$$M = \frac{NDF}{TFB} x100$$

where; W1, W2: final and initial mean weight, t: experiment time (days), AF: amount of food fed, WDF: weight of died fish, WG : weight gain, M: mortality, NDF: number of died fish, TFB: number of total fish

Table 1. Proximate compositions of the experimental diets

Feed Types	Crude Lipid*	Crude Protein*	Dry Matter (%)	Ash*	Calcium*	Phosphorus*
TA	10.54±0.24	45.64±0.19	37.11±0.02	4.56±0.02	0.0083±3x10^{-5}	0.67±0.04
BA	32.82±0.32	35.35±0.14	39.60±0.02	8.45±0.02	2.99±0.02	4.99±0.02
YY	22.47±0.54	30.36±0.26	80.10±0.13	10.86±0.46	1.91±0.02	1.21±0.03
TA+YY	8.92±0.02	47.82±0.17	44.83±0.02	9.65±0.13	1.217±0.03	0.95±0.03
BA+YY	14.79±0.52	41.02±0.02	47.31±0.16	10.34±0.14	2.66±0.02	1.68±0.02

**Values are expressed as % of dry matter basis*

All means of parameters were expressed as mean ± SE. Statistical analyses were carried out at 5% significance level with Duncan's Multiple Range Test using the SPSS computer programme (SPSS, 1999) (Table 1).

Results

Mean body weights obtained in this study for each feed type and sampling periods are shown in Table 2 and Figure 1. Mean DGR, FCR, SGR, WG and M values obtained from the present study are listed in Table 3.

The results of this study determined that the best growth (128.56± 1.75g) was recorded for the group fed with TA+YY. The groups fed with TA, BA+YY, YY and BA followed this first group from high to poor growth rates, respectively. The differences in the final body weights of the groups fed with TA+YY, BA, YY and BA+YY were statistically significant (P<0.05). Whereas the differences in final body weights of the groups fed with YY, BA+YY and TA were statistically insignificant (P>0.05). The growth rate for the group fed with BA, having lowest growth (116.01±1.22g), was statistically different (P<0.05) from the other groups (Table 2).

DGR of the groups changed between 0.21±0.01g and 0.30±0.17g. According to the statistical analyses, mean DGR value of the group TA+YY was different from the groups BA, YY, BA+YY (P<0.05), but the value of the group BA was different from all groups (P<0.05). There were statistically insignificant differences among the mean DGR values of the groups fed with YY, BA, BA+YY and TA (P>0.05).

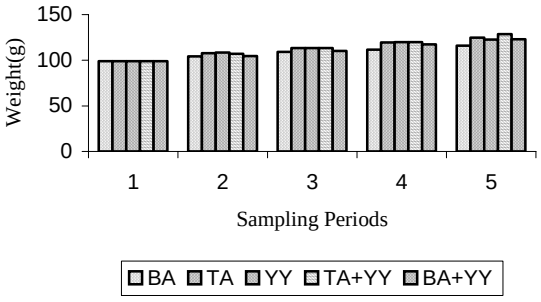

Figure 1. Mean body weights of the groups according to the sampling periods.

Table 2. Mean body weights of the groups according to the sampling periods

P*	BA	TA	YY	TA+ YY	BA+ YY
1	104.47±0.65a	108.00±0.72ab	108.54±1.41b	107.29±1.70ab	104.77±1.02ab
2	109.23±059a	113.64±1.57a	113.38±1.17a	113.46±1.52a	110.42±1.49a
3	111.69±0.88a	119.27±1.62a	119.66±0.90a	119.88±1.76a	117.39±1.23a
4	116.01±1.22a	124.87±2.04bc	122.62±0.90b	128.56±1.75c	123.06±1.35b

Different superscripts indicate significant differences between feed types according to Duncan's Multiple Range Test. P: Sampling Periods*

Table 3. Means DGR, FCR, SGR, WG and M values of the groups

Feed Types	DGR (g)	WG (%)	SGR (%)	FCR	M %
BA	0.21±0.01a	17.08±1.21a	0.20±0.01a	15.23±0.91c	7.40±4.90a
TA	0.32±0.03bc	26.03±2.06bc	0.29±0.06bc	9.51±0.93ab	14.81±3.70a
YY	0.29±0.01b	23.76±0.91b	0.27±0.01b	11.47±0.86b	16.66±3.21a
TA+ YY	0.36±0.23c	29.77±1.77c	0.33±0.02c	8.82±0.29a	12.96±4.90a
BA+ YY	0.30±0.17b	24.21±1.36b	0.28±0.01b	11.02±0.62ab	9.25±3.70a

Different superscripts indicate significant differences between feed types according to Duncan's Multiple Range Test.

The highest WG was in the group fed with TA+YY (%29.77). The groups consuming TA, BA+YY, YY and BA followed this group in terms of the WG from high to low respectively (Table 3). Mean WG of the group fed with TA+YY was significantly different from those of the groups fed with BA, YY, and BA+YY (P<0.05). The value of this parameter for the group fed with BA was different from those of all other groups (P<0.05) (Table 3).

Descending order of groups was TA+YY, TA, BA+YY, YY and BA respectively, for SGR values. SGR mean of the group fed with BA was found significantly different from those of the other groups (P<0.05). SGR differences between the groups; namely TA+YY and YY were not statistically significant (P>0.05).

The best result in terms of FCR was obtained from the TA+YY feed group (8.35±0.97). Mean FCR value of this group was different from those of the groups fed with YY and BA (P<0.05). The worst FCR mean was recorded at the group fed with BA (15.23±0.91) (P<0.05).

M values in the experiments were between 16.66±3.21% and 7.40±4.90%. The mortality values of the groups fed with BA+ YY and BA were lower than those of the other groups. Differences in the M values were statistically insignificant (P>0.05).

Discussion and Conclusion

During the course of this research, the effects of the feeds BA, TA, YY and mixtures of YY with TA or BA on European eel growth was determined. Final body weight, daily growth rate, weight gain, SGR, FCR and M were calculated at the end of the experiments using the data obtained from this study.

The results of the study showed that the fish consuming TA+YY had the best mean body weight, DGR, WG and SGR

as well at the end of this research. This group, which was fed with TA+YY, was followed by the groups fed with TA, BA+YY, YY and BA from high to low body weight, DGR, WG and SGR values respectively.

According to Güven *et al*. (2001), Matsui (1993) reported that daily growth rate means of eel were between 0.295-0.050g, but Forrest (1976) reported this value as 0.13- 0.18g. Kastelein (1983) reported that FCR and SGR were 12 and 0.51 respectively in eel having 0.21g initial mean weight and fed with trout fry feed at the rate of 6.1 % body weights. Six-seven kg fresh fish meat or 1.2- 1.5kg dry feed is necessary to produce 1 kg eel (*A. japonica*) (Sayın, n. d.). According to knowledge obtained from Güven *et al*. (2001), Egusa and Ottsuka (1957) implied that FCR was 8-20:1 for the group of fish fed with fresh fish flesh, but this value was 2:1 for the group which was fed with feed including fish meal. SGR values were found as a mean of 0.440 and 0.384 in eel (*A. anguilla*), with 50-100g initial weights fed with commercial trout fry pellet feed and special feed prepared in the laboratory (Baştürk *et al*., 2003).

In the present study, DGR values varied between 0.21±0.01g and 0.36±0.23g. These values are rather higher than those reported by Forrest (1976) and Matsui (1993) according to Güven *et al*. (2001).

In this research, feeding rate was applied at the rate of 3% of fish body weight. The lowest FCR was determined as 8.82±0.29 at the group fed with TA+YY. This value is lower than FCR value of the group supplied with artificial feed reported by Kastalein (1983). FCR of the group fed with YY (11.47±0.86) in this study is close to but lower than that of reported by Kastalein (1983). It is a well known fact that FCR decreases when eel grows bigger (Güven *et al*., 2001). For this reason, it can be said that the FCR obtained in this study is good in spite of the fact that the big eels were tested during the course of this research. It can also be stated that differences between results could be due to the culture conditions applied in this study. FCR reported by Sayın (n. d.) is better than those obtained in the present study. These differences can be because of the fact that different species and feed types or ingredients were experimented in these studies. FCR values belonging to the group fed with BA (15.23± 0.91) in this study is between the values for the fish groups fed with fresh fish flesh reported by Güven *et al*. (2001). One of the most important results that needs to be taken into consideration here is that the results observed in the group fed with BA in the present study are between the values which were reported for fresh whole fish in the previous studies. Although the BA which was the waste products of fish markets containing fish head, skin, internal organs and fins, do not contain high nutrition levels as the fresh whole fish, it is impressive to record that the growth rate for this group was within the range reported for the groups fed with whole fresh fish in previous studies. SGR means reported by Kastalein (1983) and Baştürk *et al*. (2003) are higher than the highest value obtained in the present study (0.33±0.02 in the group TA+YY).

An important research was carried out to determine the possibility of the replacement of poultry by-product meal, oil and fish meal, oil in eel feed by Gallagher and Degani (1988). They reported that the groups given feed containing fish meal and oil grew better in their study, since these feeds had higher n3 fatty acid value. However, if poultry by- product meal and oil mixed with fish meal and oil at the rate of 50%, fish growth was not affected (Gallagher and Degani, 1988). By- product meal generally consists of chicken neck, feet, liver, gut, undeveloped organs, feather and blood or some of these parts. If feather is added, protein value and also biological value of by- product meal decreases because of the treatment with high temperature during processing. Moreover digestion degree of feather is low (Fred and Bisplinghoff, 2000). Not all the wastes but only some internal organs of poultry slaughterhouses were used in the present research. Thus it can be said that there was no decrease in biological values of feed materials in this study unlike the studies where poultry-by product meal was used.

The weight gain in the groups fed with TA+YY and TA was much more than that of the group fed with YY. This can be explained by the fact that the eel can accept the feed from natural sources easier than the artificial feeds, and prefer the feed from natural sources more than to those of artificial sources. Moreover it can be stated that artificial feeds have plant based- feed ingredients from which eel cannot benefit easily.

There were statistically insignificant differences ($P>0.05$) observed among the DGR, WG and SGR values of the group TA+YY, which had the highest growth rate, and the group TA, which had the second highest growth rate, during the eighty days experimental period.

Therefore, it can be suggested that the feeding the eel having this size with TA can be useful. Thus there is no need for any effort or expense to add the YY. On the other hand, the body weight means for the groups fed with YY and BA+YY are statistically similar ($P>0.05$). Therefore it can be concluded that mixing YY with BA is more advantageous than giving YY alone. In another word, this way not only YY can be economized but also existent BA can be utilized as well.

Fish meal is the main and one of the most expensive elements of artificial fish feeds, which in turn increases the cost of the feed. In accordance with the demands of cultured fishes and also availability of traditional feed materials and type, fish meal still keeps its importance. However, it is obvious that in addition to artificial feed discarded fish and fish wastes from the local fish markets can be utilized to feed the eel (Güven *et al*., 2001). Poultry wastes have increased in the countries having developed poultry industry (Gallagher and Degani, 1988; Çizmeci *et al*., 2004). During the recent years, the fishery and poultry industries of Turkey have also developed significantly (Çelikkale *et al*., 1999; Çizmeci *et al*., 2004; Altun *et al*., 2003). Daily chicken slaughtering in Turkey is approximately 3320 tones currently and continuing to increase gradually. About 17 tones waste appear daily in a slaughterhouse, which has only 50 and 75 tones of capacity. If

a slaughterhouse has a processing facility for wastes, they can be evaluated as rendering products; otherwise they are wasted as solid materials. The fishes sold in fish markets are generally cleaned for customers by removing internal organs, and sometimes by cutting head and fins in Turkey (Altun *et al*., 2003). These dense organic solid wastes cause environmental pollution and energy loses causing serious problems. However, it is possible to convert these waste products into fish meal or by-product meal and then produce feed in factories. For doing so, wastes need to be transported to factories and they need to be processed. However, this procedure is troublesome, time consuming and expensive. Instead of processing these waste products to make artificial feed, they can be utilized by adding them directly into food chain via feeding them to eel in the fish farms, which are located in close proximity to the local fish markets and slaughterhouses.

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