

# The Advantages of Artificial Neural Networks to Give Length-Weight Relations and Comparison of Growth

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## ABSTRACT

*This study has two main purposes. The first one is to compare the performances of Logistics, Gompertz, Schnute and von Bertalanffy models according to the determination coefficient ( $R^2$ ) and Mean Squared Error criteria, and these comparisons are aimed to be discussed in terms of gender.*

*For this purpose 329 female and 319 male individuals' data on *P. Quadrilineatus* (Bloch, 1790) which is one of lesepsian species in Turkish marine waters were used. As a result of the comparisons, it was concluded that the best growth model varied on the basis of genders. For example, for male individuals Gompertz is the best growth model with highest  $R^2$  (0,745) and the lowest Mean Squared Error (0,717) values. For females, Schnute and von Bertalanffy models have the best results with the highest  $R^2$  (0.813) and the lowest Mean Squared Error (0.369) values.*

*The second purpose of this study is to make comparisons regarding the use of Artificial Neural Networks and Linear Regression Method to determine the Length -Weight relationships. Comparisons are made according to  $R^2$ , Mean Squared Error and Mean Absolute Percentage Error criteria. Although the results of these criteria are very close to each other, it can be said that the results obtained for Artificial Neural Networks are slightly better for overall data. The use of Artificial Neural Networks is more convenient since it is a faster and less annoying (does not need transformation) method compared to Linear Regression Method, especially in length-weight estimation for *Pelates quadrilineatus* (Bloch, 1790) species.*

**Keywords:** Artificial neural networks, Gompertz models, logistic models, pelates *quadrilineatus*, schnute models.

**Mathematics Subject Classification:** 62P12,62J05, 62G99,92B20

## 1. INTRODUCTION

Length-weight and age-length relationships in living things are frequently used in fishery and in many ecological areas for species' formation, growth rate, bio-diversity, stock estimation, biomass calculation or growth modeling of the creature.

There are many growth models used to examine these relationships such as von Bertalanffy (von Bertalanffy, 1938), Logistics (Karkach, 2006), Gompertz (Gompertz, 1825; Ricker, 1975), Schnute

(Schnute, 1981). Von Bertalanffy growth model has been used frequently in literature studies on growth in fishery. In addition, there are many studies in the literature that compare different growth models using statistical criteria and examine the performance of these models (Braccini et.al., 2007; Katsanevakis, 2006; Aragón-Noriega et.al., 2015; Zhu and Liang, 2009). It is possible that the performances of growth patterns may vary according to the species or gender of living things.

The number of lessepsian species has increased especially during the last decade in Turkish marine waters (Dogdu et al., 2016; Gurlek et al., 2016a, 2016b). *Pelates quadrilineatus* (Bloch, 1790) is one of lesepsian species. The fourlined terapon, *P. quadrilineatus* (Bloch, 1790) is a coastal species, often found in brackishwaters; common in estuaries bottoms at depths ranging from 0 m to 20 m (Golani et al., 2016; Froese and Pauly, 2017). In this study, different growth models are emphasized as an alternative to the von Bertalanffy growth model, which is frequently used in *P. quadrilineatus* individuals.

When examining the age-length relationship, four different models, such as von Bertalanffy, Logistics, Gompertz, Schnute, were taken into consideration and compared according to the genders. Comparisons were made separately on the basis of genders using the Determination Coefficient ( $R^2$ ) and Mean Squared Error (MSE) criteria. At the end, the most appropriate models were suggested and the parameter estimates of these models were given to.

In addition to the proposed models, relationship between length-weight was estimated by Linear Regression Models (LM) using data from *P. quadrilineatus* fish species, MSE and  $R^2$ , statistics of the parameters were estimated according to gender were given.

In addition, Artificial Neural Networks (ANNs) method, which has been used as an alternative to traditional models like Linear Regression Models (LM) in recent years, is also discussed in this study. Because the ANNs method is quite good at analyzing the data exactly, determining the structure of the relationships and adapting the system to changing conditions (Faris et al., 2014).

Moreover, ANNs method gives faster and more flexible results in ecological studies compared to traditional models like LM (Similar et.al., 2017; Sun, 2009; Türeli Bilen et.al., 2011; Özcan, 2019).

When the literature studies in the field of fisheries are examined, it is seen that the ANNs method is used to examine the species (Haralabous and Georgakarakos, 1996; Mastrorillo et. Al., 1997). ANNs method is also used in studies on fish species determination (Cabreira et. Al. 2009). However, there is no analysis in the literature using the ANNs method belonging to the *Pelates quadrilineatus* species.

For this reason, in this study, as an alternative to the length-weight relationship obtained with LM, the length-weight relationship is discussed using the ANNs method. The length-weight relationship obtained by ANNs method was compared to the model obtained with LM by considering the gender.

Multi Layer-Perceptron (MLP) algorithm is a feedforward network, one of the supervised learning models (Suryanarayana et. Al., 2008; Çılgışar and Ünal, 2019) and it was used in ANNs. The graph of the artificial neural network model was also presented.  $R^2$ , MSE and Mean Absolute Percentage Error (MAPE) were used as comparison criteria when comparing ANNs and the linear regression model. As a result, it has been shown that ANNs can be used as an alternative to traditional methods for *P. quadrilineatus* species.

## 2. MATERIALS AND METHODS

Data on *P. quadrilineatus* species were obtained from monthly trawl shootings from Iskenderun Bay, Yumurtalık, between July 2014 and June 2015. Sub-samples were taken from the fish samples obtained by the method suggested by Holden and Raitt (1974). On these samples total length (1mm precision)

and weight (0.01 g precision) of each individual were measured using a digital caliper and digital scale, respectively. Sagittal otoliths were used for *P. quadrilineatus* age determinations.

According to Table 1, lengths are ranged from 6.60 cm to 15.40 cm, ages are ranged from 0 to 4 and weights are ranged from 3.52 g to 46.75 g. Also deviations of total length, weight and age are 1.63, 7.53 and 0.93, respectively for overall data. These values are 1.41, 7.33, 0.88 for females and 1.69, 7.0, 0.92 for males. In Table 1, it is also seen that females are heavier than males. In terms of average age, females are larger than males.

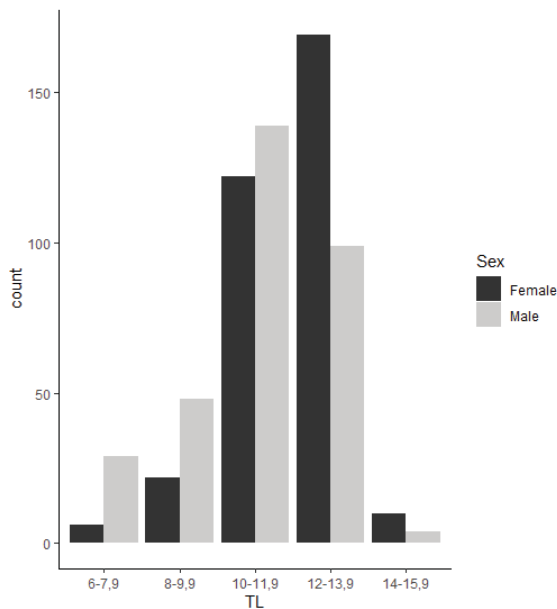
**Table 1.** Descriptive statistics for *P. quadrilineatus*

|         |                   | Minimum | Maximum | Mean  | Standart Deviation |
|---------|-------------------|---------|---------|-------|--------------------|
| Overall | Total Length (cm) | 6.60    | 15.40   | 11.31 | 1.63               |
|         | Weight (g)        | 3.52    | 46.75   | 18.86 | 7.53               |
|         | Age               | 0       | 4       | 1.63  | 0.93               |
| Female  | Total Length (cm) | 7.50    | 15.40   | 11.80 | 1.41               |
|         | Weight (g)        | 5.22    | 46.75   | 21.14 | 7.33               |
|         | Age               | 0       | 4       | 1.85  | 0.88               |
| Male    | Total Length (cm) | 6.60    | 14.50   | 10.81 | 1.69               |
|         | Weight (g)        | 3.52    | 37.90   | 16.51 | 7                  |
|         | Age               | 0       | 4       | 1.41  | 0.92               |

The frequency distribution of length according to gender is presented in Figure 1.

As can be seen in Figure 1, females are longer than males. The minimum total length of females is 7.50 cm and the maximum total length is 15.40 cm while the minimum total length of men is 6.60 cm, the maximum total length is 14.50 cm.

**Figure1.** Length frequency by gender



## 2.1. Growth Models

Modeling with growth data constitutes the most efficient way to understand biological development. Making predictions for the future using growth models is important in terms of creating strategies for issues such as increasing productivity, proper use of resources, and understanding population dynamics. This section provides information about four commonly used growth models.

### 2.1.1 Von Bertalanffy Growth Model

$$L_t = L_{\infty} e^{-k(t-t_0)}$$

Meanings of the parameters are presented respectively:  $L_t$  is length at time  $t$ ;  $L_{\infty}$  is the asymptotic length (average length at maximum age);  $k$  is the Brody growth parameter measuring the exponential rate of approaching the asymptotic size;  $t_0$  defines an age at which the fish would have zero length (Francis, 1988; von Bertalanffy, 1938).

### 2.1.2 Gompertz Growth Model

The model of Gompertz is as follows:

$$L_t = L_{\infty} e^{-e^{-k(t-t_0)}}$$

The parameters are same as von Bertalanffy growth model (Gompertz, 1825; Ricker, 1975).

### 2.1.3 Gompertz Growth Model

$$L_t = [L_1^b + (L_2 - L_1)^b \frac{1 - e^{-a(t-T_1)}}{1 - e^{-a(T_2-T_1)}}]^{1/b}$$

$L_1$  and  $L_2$  are the average lengths at  $T_1$  (the youngest age) and  $T_2$  (the oldest age in the sample), respectively;  $a$  and  $b$  are constants (Schnute, 1981). Note that,  $L_2$  is not the average size at the theoretical maximum age like,  $L_{\infty}$ , but the average size at the oldest age in the sample.

### 2.1.4 Logistic-Karkach Growth Model

$$L_t = \frac{L_0 L_{\infty}}{L_0 + (L_{\infty} - L_0) e^{-kt}}$$

$L_0$  is the average length at birth and the other parameters are same as von Bertalanffy growth model (Karkach, 2006).

## 2.2 Artificial Neural Networks

Artificial neural networks are a technique that makes predictions for the future by using previous information and the relationships between this information like the human brain. Just like biological neural networks, ANNs consist of neural networks, snaps, and neurons. In other words, ANNs are

mathematically modelled algorithms that mimics the brain functions (Ataseven, 2013). These algorithms identify and learn relationships that reside in data, model the complex relationship between inputs and outputs in data, and can work with many variables (Suryanarayana et.al., 2008; Ozcan, 2019). Artificial neural networks can be applied to complex functional relationships. Unlike generalized linear models, no linearity condition is required between variables. This makes ANNs a valuable statistical tool.

ANNs consists of three layers. These layers are called as input, hidden and output layers. A single neuron consists of a single output which is determined by an activation function (Priddy and Keller, 2005).

$$o(x) = f \left( w_0 + \sum_{i=1}^n w_i x_i \right) = f(w_0 + w^T x)$$

where  $w_0$  intercept (constant),  $w=(w_1, \dots, w_n)$  synaptic weights and  $x=(x_1, \dots, x_n)$  variables matrices.

In this study, the "FSA" package developed by Ogle et. al. (2018) was used in the R program to examine the age-length relationship. For the artificial neural network, the "neuralnet" package developed by Günther and Fritsch (2010) in the R program was used.

#### Statistical Criteria:

$R^2$ , MSE and MAPE, which are frequently used as comparison criteria in similar studies in the literature (Ebtehaj et.al., 2014) were also used in this study.

MSE is the mean of the squared of the difference of the estimate and the real data.

$$MSE = \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{n}$$

$R^2$  gives the goodness of fit measure for linear regression models and uses predicted and observed values and mean.

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{\sum_{i=1}^n (y_i - \bar{y})^2}$$

MAPE is used to measure the accuracy of the predicting data and uses the predicted and observed values.

$$MAPE = \frac{100\%}{n} \sum_{i=1}^n \left| \frac{y_i - \hat{y}_i}{y_i} \right|$$

where  $\hat{y}_i$  and  $y_i$  are predicted and observed values, respectively and  $\bar{y}$  is the mean. These given formulas for  $R^2$  and MSE were used in the whole study but MAPE was used only in the second part of the study.

While evaluating the performance of each model, MSE, MAPE and  $R^2$  values are taken into consideration. Smaller MSE and MAPE values and higher value of  $R^2$  indicates that the model is better. The metrics' values under specified conditions (small / high) indicate how well the model fits the data and how much the predicted values approach the actual values (Gasmi et. al., 2018).

### 3. ANALYSIS AND FINDINGS

With 329 female and 319 male individuals were studied. Detailed information for the data is given in Table 1.

### 3.1. Age-Length Relationship Model Comparison and Parameter Estimates

In this section, von Bertalanffy, Schnute, Gompertz, Logistic-Karkach growth models were compared according to  $R^2$  and MSE values, taking into account the gender factor.

When the models are compared according to  $R^2$  and MSE values without considering gender, the model with the highest  $R^2$  and the lowest MSE value appears as von Bertalanffy. However, if comparisons are made based on genders instead of this approach that does not take gender into account, it is observed that the performance of the models also differ.

**Table 2.** Von Bertalanffy, Schnute, Gompertz, Logistic-Karkach Models Comparison

| Growth Models / Statistics | $R^2$ | MSE   |
|----------------------------|-------|-------|
| <b>Overall</b>             |       |       |
| Von Bertalanffy            | 0.813 | 0.369 |
| Schnute                    | 0.791 | 0.552 |
| Gompertz                   | 0.790 | 0.555 |
| Logistic-Karkach           | 0.788 | 0.560 |
| <b>Male</b>                |       |       |
| Von Bertalanffy            | 0.744 | 0.718 |
| Schnute                    | 0.744 | 0.718 |
| Gompertz                   | 0.745 | 0.717 |
| Logistic-Karkach           | 0.745 | 0.718 |
| <b>Female</b>              |       |       |
| Von Bertalanffy            | 0.813 | 0.369 |
| Schnute                    | 0.813 | 0.369 |
| Gompertz                   | 0.811 | 0.373 |
| Logistic-Karkach           | 0.809 | 0.378 |

For example, when the results of male individuals are considered in Table 2, it is seen that the model with the highest  $R^2$  and the lowest MSE value is the Gompertz growth model. When the results for females are examined, it is seen that the model with the highest  $R^2$  value and the lowest MSE value is the Schnute and von Bertalanffy models. It can be seen that instead of the von Bertalanffy growth model, which is constantly used in fishery studies, different models should be used for female and male individuals.

Growth parameters of all models used for comparison are given in Table 3.

**Table 3.** Estimated growth parameters for the models

| Models             | Overall      |        | Male         |        | Female       |        |
|--------------------|--------------|--------|--------------|--------|--------------|--------|
|                    | Parameter    | Values | Parameters   | Values | Parameters   | Values |
| <b>Von</b>         |              |        |              |        |              |        |
| <b>Bertalanffy</b> | $L_{\infty}$ | 15.065 | $L_{\infty}$ | 14.650 | $L_{\infty}$ | 15.626 |
|                    | K            | 0.411  | K            | 0.443  | K            | 0.348  |
|                    | $t_0$        | -1.798 | $t_0$        | -1.709 | $t_0$        | -2.160 |
| <b>Schnute</b>     |              |        |              |        |              |        |
|                    | $L_1$        | 7.875  | $L_1$        | 7.777  | $L_1$        | 8.255  |
|                    | $L_2$        | 13.678 | $L_2$        | 13.481 | $L_2$        | 13.794 |
|                    | K            | 0.411  | K            | 0.443  | K            | 0.348  |
| <b>Gompertz</b>    |              |        |              |        |              |        |
|                    | $L_{\infty}$ | 14.477 | $L_{\infty}$ | 14.054 | $L_{\infty}$ | 15.141 |
|                    | K            | -0.504 | K            | -0.527 | K            | -0.524 |
|                    | $t_0$        | 0.569  | $t_0$        | 0.619  | $t_0$        | 0.459  |
| <b>Logistic-</b>   |              |        |              |        |              |        |
| <b>Karkach</b>     | $L_{\infty}$ | 14.108 | $L_{\infty}$ | 13.677 | $L_{\infty}$ | 14.846 |
|                    | $L_0$        | 7.956  | $L_0$        | 7.799  | $L_0$        | 8.487  |
|                    | K            | 0.726  | K            | 0.798  | K            | 0.564  |

By Table 3, it is seen that the asymptotic length of females is much longer than males in all models. If the asymptotic length comparison of the models is made, it is observed that the longest asymptotic length is estimated by von Bertalanffy growth model.

### 3.2. Length-Weight Model Comparison and the Model

The length-weight relationship obtained in living things gives information about the living things themselves, their living environments and the characteristics of the population. At the same time, when this relationship is obtained, it is possible to estimate length from weight or vice versa using the data obtained from a particular species. In this section, two different methods such as LM and ANNs have been used to determine the length-weight relationship and these methods are compared.

### 3.2.1 Length-Weight Relationship with LM Method

The formula  $W = aL^b$  (Ricker, 1973) was used to determine the length-weight relationship via the LM method. Here, "a" refers to the intercept and "b" to the slope / exponent parameters where W is the weight, and L is the total length. Exponential relationship between weight and length can be seen in Figure 2. In order to apply Linear Regression, logarithmic transformation was performed (Ricker, 1973; Amin and Jacobs, 2020) and the relationship between length-weight was estimated by linear regression.

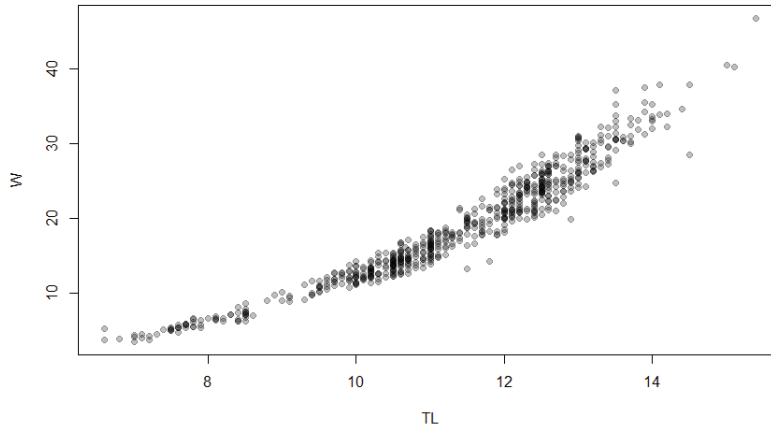


**Figure 2.** Weight-Length Graph of the Model

Accordingly, the model obtained from all data regardless of gender is  $W=0.0120L^{3.008}$  and the MSE and  $R^2$  of this model is 2.59 and 0.96, respectively. In other words, 96% of the increase in weight can be explained by the increase in length. It is then possible to estimate the weight of fish by length information with high precision for *Pelates quadrilineatus*.

**Table 4.**  $R^2$  and MSE values for LM parameters

| Linear Regression Parameters | a     | b     | Confidence Interval for b | $R^2$ | MSE   |
|------------------------------|-------|-------|---------------------------|-------|-------|
| Overall                      | 0.012 | 3.008 | 2.968-3.048               | 0.955 | 2.585 |
| Male                         | 0.013 | 2.965 | 2.910-3.020               | 0.953 | 2.322 |
| Female                       | 0.011 | 3.065 | 2.999-3.132               | 0.949 | 2.769 |

The parameters estimated according to the gender, MSE and  $R^2$  statistics and the confidence interval for the b parameter are as in Table 4. Accordingly, the model created for females is  $W=0.0105L^{3.0653}$ ,  $R^2 = 0.949$ , while the model created for males is  $W=0.0133L^{2.9646}$ ,  $R^2 = 0.953$ . With these results, as in the model created for all data, it can be said that with 95% certainty, length by using length or weight by using length can be estimated with models created according to gender.

### 3.2.2 Length-Weight Relationship with ANNs Method

In recent years, it was stated that the ANNs method was frequently used in determining the length-weight relationship (Sun, 2009). Therefore, in this study, ANNs model is discussed and Multi Layer-Perceptron algorithm, which is a feedforward network in ANNs, is used.

In the preprocessing stage of the data, it was first examined whether there is missing data points in the data set. As a result of this examination, it was determined that there was no missing data points and data splitting process was conducted. Data splitting process is very important for modeling. With this procedure, the dataset is divided into two sets, train and test. According to this process the model is trained with train dataset and then this method is tested with test set. For this purpose, using the split method in R, 70% of data and 30% of data were randomly transferred to train and test sets respectively. After this process the data set was normalized to execute the ANN procedure (Peter and Precious,2018).

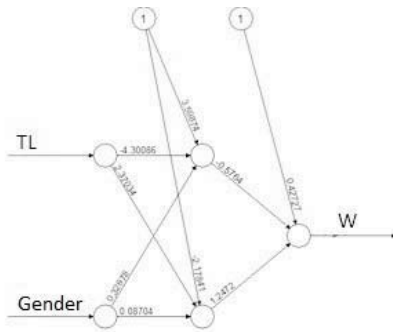


**Figure 3.** Artificial Neural Network Model

The applied artificial neural network model is given in Figure 3. As seen in Figure 3, ANNs consists of two input variables (total length and gender) and one output variable (weight). Again, there are two hidden layers according to the graphic. Input layer is linked to hidden layer; the hidden layer is linked to the output layer with weights. The information obtained is transmitted to other units with these weights. Weight estimates according to MLP algorithm and comparison of these estimates with real values according to MAPE criteria are shown in Table 6.

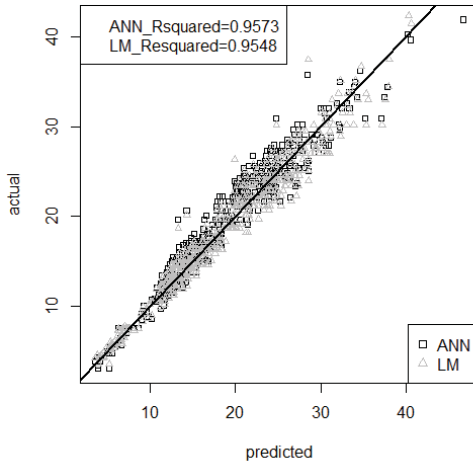


**Figure 4.** ANNs vs LM predicted-actual values graph

The graph of the predicted values obtained by applying the Linear Regression and MLP models to the data and the values belonging to the actual data are shown in Figure 4. So, Figure 4 shows that each model fits the data very well and summarizes how close the predicted values are to the actual values. Statistical values regarding the performance of the models also prove this situation (Tables 4 and 5).

**Table 5.**  $R^2$  and MSE values for ANNs

| ANNs    | $R^2$ | MSE   |
|---------|-------|-------|
| Overall | 0.957 | 2.496 |
| Male    | 0.954 | 2.219 |
| Female  | 0.949 | 2.693 |

According to Table 5, the error of the ANNs obtained regardless of gender is 2.496. It is seen that this value is slightly better than the MSE value obtained for LM. These values belonging to the ANNs model when the genders are considered separately are  $MSE = 2.693$  and  $R^2 = 0.949$  for females,  $MSE = 2.219$  and  $R^2 = 0.954$  for males. When LM and ANNs methods are compared by considering the genders, it is seen that ANNs give better results with respect to MSE and  $R^2$  criteria.

Real values for weight, weights obtained from ANNs estimation and weights estimated from LM and MAPE values of both models are given in Table 6 according to length groups. As seen in Table 6, the performance of the MAPE values of both models varies according to age and gender. However, it is seen that the average MAPE value is lower in the ANNs model.

**Table 6.** MAPE values for LM and ANNs by gender

| <b>Length<br/>groups (cm)</b> | <b>Gender</b> | <b>Real<br/>Weights<br/>(gr)</b> | <b>ANN<br/>Weights<br/>(gr)</b> | <b>ANN<br/>MAPE</b> | <b>LM<br/>Weights<br/>(gr)</b> | <b>LM<br/>MAPE</b> |
|-------------------------------|---------------|----------------------------------|---------------------------------|---------------------|--------------------------------|--------------------|
| <b>6.0-7.9</b>                | Overall       | 4.988                            | 5.054                           | 0.051               | 5.122                          | 0.066              |
|                               | Male          | 4.873                            | 4.883                           | 0.050               | 5.059                          | 0.069              |
|                               | Female        | 5.623                            | 5.332                           | 0.052               | 5.483                          | 0.026              |
| <b>8.0-9.9</b>                | Overall       | 10.280                           | 10.263                          | 0.056               | 9.625                          | 0.058              |
|                               | Male          | 9.233                            | 9.242                           | 0.057               | 9.243                          | 0.057              |
|                               | Female        | 10.088                           | 10.644                          | 0.068               | 10.488                         | 0.058              |
| <b>10.0-11.9</b>              | Overall       | 15.588                           | 15.571                          | 0.066               | 15.601                         | 0.063              |
|                               | Male          | 15.286                           | 15.239                          | 0.060               | 15.359                         | 0.062              |
|                               | Female        | 15.475                           | 15.492                          | 0.067               | 15.825                         | 0.063              |
| <b>12.0-13.9</b>              | Overall       | 25.424                           | 25.333                          | 0.065               | 25.352                         | 0.064              |
|                               | Male          | 24.108                           | 24.137                          | 0.073               | 24.157                         | 0.070              |
|                               | Female        | 25.832                           | 25.793                          | 0.067               | 25.99                          | 0.060              |
| <b>14.0-15.9</b>              | Overall       | 35.730                           | 34.222                          | 0.051               | 35.673                         | 0.055              |
|                               | Male          | 33.310                           | 33.428                          | 0.008               | 33.070                         | 0.076              |
|                               | Female        | 33.843                           | 33.816                          | 0.055               | 36.669                         | 0.043              |
| <b>Mean for<br/>MAPE</b>      |               |                                  |                                 | 0.056               |                                | 0.059              |

#### 4. DISCUSSION AND CONCLUSION

In this study, age-length and length-weight relationships of *P. quadrilineatus* fish species from Adana-Yumurtalik region were examined, and it is the first study that uses ANNs for the length-weight relationships for this species. The findings of the study contribute to the literature in terms of providing the best models of the Pelates *quadrilineatus* fish species on the basis of genders and suggesting the ANNs method as an alternative to LM.

In the study, while examining the relationship between age and length, models such as Logistics, Gompertz and Schnute were considered as well as the von Bertalanffy growth model which is constantly used in the literature, and the parameter values of all these models were given. In addition, comparisons of these models were made separately on the basis of genders using  $R^2$  and MSE criteria.

The fact that the some specific models are frequently used in estimation of parameters in aquaculture and using these models due to easiness brings along prejudices about other models. These biases create the perception that different models developed or proposed will not be used even if their performance is good, creating limitations in parameter estimation.

In contrast to these opinions, findings obtained in the light of these criteria indicated the necessity of using different models for male and female individuals.

The age-length or length-weight relationship in living things is frequently used in fishery and in many ecological areas for species formation, propagation rate, diversity, stock estimation, biomass calculation or growth modeling of the living creature.

The relationship between length and weight obtained in living things not only gives information about the condition of the living things, but also provides guidance on the living environments of these creatures, suitability of the environments, nutrition surveys and closed seasons for hunting. For this reason, it has become the primary goal for scientists to obtain the models that give the length -weight relationship best. Because, when the length -weight model is obtained it is possible to estimate length from weight data or weight from length data. Determination of length-weight relationship with linear regression models and growth models are the methods that are frequently used in fisheries, especially in determining the length of the fish caught and in estimating the biomass depending on the length.

In this study, the use of ANNs method as an alternative to the traditional LM method, which gives the length-weight relationship for the *Pelates quadrilineatus* species, is discussed. Separate models are established by taking gender into consideration. ANNs method is valuable in terms of giving faster and more precise results due to its structure. At the same time, the ANNs method is much better at analyzing data, determining the structure of relationships, and adapting the system to changing conditions (Brosse, et al., 1999; Faris et al., 2014).

In this study, comparisons were made for LM and ANNs by considering  $R^2$ , MSE and MAPE values. It has been observed that these values for ANNs and LM are quite close and compatible with each other. It was even reflected on the obtained values that both  $R^2$  and MSE values for all data were better for ANNs.

In this case, when there is a non-linear relationship between dependent and independent variables it shown that it is more appropriate to use ANNs because it is a faster and less costly method compared to LM, especially in length-weight estimation for *Pelates quadrilineatus* species without any transformation.

Nevertheless, the fact that ANNs has not been used before in studies of the *Pelates* species makes it difficult to compare. In future studies, predictions should be reproduced with hybrid algorithms that can be combined with the ANNs algorithm.

However evaluating the information belonging to this species from basins other than the Yumurtalık Basin and discussing whether similar results would be obtained by applying different models could pave the way for the study.

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