ARTIFICIAL NEURAL NETWORKS MODEL BIOMETRIC FEATURES OF MARINE FISH SAND SMELT

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ABSTRACT: In this study was investigated some biometric properties of the sand smelt with ANN’s, *Atherina boyeri* Risso, 1810, population in Yamula Dam Lake. Twenty-three morphometric characters of samples were measured. The total length of individuals which were caught between 6.40 and 10.20 cm, and their weight (*W*) were ranged between 1.50 and 7.31 g. The effect of Artificial Neural Networks was investigated in predicting the statistical of fishery industry. The present study provides the first information on the biometric properties of *Atherina boyeri* in Yamula Dam Lake by Artificial Neural Networks.

KEYWORDS: *Atherina boyeri*; sand smelt; biometric properties; Yamula Dam Lake; ANNs

INTRODUCTION

The fish population was sampled to distinguish and discriminate body structure, biological body shape and organ, and to determine morphometric and morphological differentiation and diversity for the meristic use of the fish population (Melvin et al., 1992; Park et al., 2001).

Quantitative morphology of fish can be examined by morphometric and meristic techniques. The scientific definition of fish is considered as the two main numerical techniques used in the process (Barriga-Sosa et al., 2004; Pinheiro et al., 2005). Through the morphometric method, it is provided to distinguish countless fish stocks worldwide (Dwivedi & Dubey, 2013). Morphometric characters are not only used to understand the taxonomy, but are also used to evaluate a species’s health and reproductive environment (Austin et al., 1999).

In addition to traditional morphometry, image processing techniques, which are one of the modern techniques, are also used in the definitions (Cavalcanti et al., 1999). More comprehensive and precise data collection, measurement to geometric shapes and the use of modern geometric techniques have been developed alongside traditional approaches (Rohlf, 1990; Bookstein, 1991). As an alternative to traditional morphometrics, a box-truss network between landmark is proposed by Strauss & Bookstein (1982). Image analysis systems have gained an important place in the development of traditional morphometric techniques (Cadrin & Friedland, 1999). In recent years; morphometric and genetic data are combined and used by researchers Ergüden & Turan, 2005; Espinosa – Lemus et al., 2009).

Fish classification systems make it easier to monitor fish counting, stocks that assess ecological impacts, and fish behavior (Benson et al., 2009). D’Elia et al. (2014) used a

This species mainly inhabits coastal estuarine waters and lagoons, over a wide range of salinities and more rarely, freshwaters (Freyhof & Kottelat, 2008). They are short-lived fish and can reach up to 4 years of age, although the average is 1-2 years (Kottelat & Freyhof, 2007).

*A. boyeri*, a species of euryhaline, continues to live in marine ecosystems. Also, it continues to exist in freshwater in character in Turkey (Kirankaya et al., 2014; Gençoğlu & Ekmekçi, 2016; Benzer, 2018). *Atherina boyeri* is euryhaline: the adults migrate to sea in autumn and enter the lagoons in spring for reproduction (Congiu et al., 2002). It is euryhaline, mostly inhabiting coastal and shallow brackishwaters including coastal lagoons, salt marshes, marine waters of the western Atlantic Ocean and Mediterranean Sea and inland waters (Leonardos & Sinis 2000; Pallaoro et al.2002; Andreu-Soler et al.2003; Bartulovic et al., 2004; Koutrakis et al., 2004; Kottelat & Freyhof, 2007).

Turkey has many different features about the investigation of *A. boyeri* having spread quickly and economically important inland waters (Tarkan et al., 2007; Özeren, 2009; Çetinkaya et al., 2011; Taskavak et al., 2012; Kucuk et al., 2012; Kirankaya et al., 2014; İlhan & Sarı, 2015; Gençoğlu & Ekmekçi, 2016; Saç et al., 2016; Ünlü et al., 2017; Benzer & Benzer, 2017; Benzer, 2018; Benzer & Benzer, 2019; Partal et al., 2019).

Artificial Neural Networks (ANNs) is the most significant tool for extracting information from data and for making decisions. At this point, in fishery industry applying modern techniques related to ANNs instead of conventional methods is gaining importance. ANNs provide generalized learning based on training process (Bon & Hui, 2017). Thus, ANNs has non-linear structure. Besides, ANNs outperform conventional methods in terms of performance measures and they can detect non-linear relations without any hypothesis (Türeli et al., 2011; Benzer, 2015; Benzer & Benzer, 2016; Benzer & Benzer, 2017; Benzer & Benzer, 2018; Benzer & Benzer, 2019; Özcan & Serdar, 2019; Sangun, 2019).

In the research describes the area where reveals the biometric data of *Atherina boyeri* population. The present study provides the first information on the biometric properties of *Atherina boyeri* in Yamula Dam Lake by ANNs model.

**MATERIALS AND METHOD**

Yamula Dam Lake, Kayseri 30 km north of the town of Yamula is on the Kızılırmak River in Turkey, and lies within the coordinates of 38°58′4″N 35°26′44″E (Fig. 1). Its purpose is energy and production in Central Anatolia Region.

The samples (*Atherina boyeri* Risso, 1810) were collected from Yamula Dam Lake. During the study, 30 fish specimens were caught in 2018. The samples were preserved in %4 formaldehyde solution and measured weight to the nearest 0.01g and total, fork and
standard length to the nearest 0.01 mm. Fig. 2 shows the measurement ranges and example A. boyeri.


ANNs, inspired by biological neural networks and revealed some performance characteristics similar to biological neural networks is an information processing system (Faussett, 1994; Sivanondom et al., 2006). ANNs that simulate the way the human brain works simply can learn from data, generalize, work with an unlimited number of variables, and so on has many important features (Huang et al., 2006). The smallest units underlying the operation of ANNs are called artificial nerve cells or process elements. The simplest artificial nerve cell consists of 5 main components: inputs, weights, splicing...
function, activation function and output. The ANNs calculations (Krenker et al., 2011) were used of the relationships.

\[ \sum_{i=1}^{p} W_i x_i + b y = f(n) = f \left( \sum_{i=1}^{p} W_i x_i + b \right) \]

where, \( x_i \) = inputs, \( f(n) \) = activation function; \( y_i \) = output value. In order to solve the developed ANNs problem, back propagation networks were used as a trained supervised learning method. The data were divided into three equal parts: training, validation and test sets.

The ANNs calculations in MATLAB, the data of fish are divided into three parts as training, validation and test sets as 70 %, 15 % and 15 % respectively. The statistical analyses were performed using SPSS software (SPSS Inc. USA) whereas the ANNs model was studied by the use of Matlab Release 2015a program. Mean Absolute Percentage Error (MAPE) were used as the two performance criteria.

\[ MAPE = \frac{1}{n} \sum_{i=1}^{n} \frac{|e_i|}{Y_i} \times 100 \]

Where, \( Y_{io} \) = actual observation value, \( Y_{ip} \) = prediction value, \( e_i \) = difference between the actual value and prediction value, \( n \) = the number of total observations.

In the ANNs, the input values were twenty three morphometric characters (without weight data) whereas the estimated output value was weight (W). The structure of the network created for the input and output data in the ANNs is presented in Fig. 3. A feed forward back propagation algorithm train lm as the training function, learn gdm as the learning function and logs is as the activation function are used in the established network.

Fig. 3. ANNs model biometric features of *A. boyeri*. 
RESULTS AND DISCUSSION

A sample sand smelt (n= 30) was collected from Yamula Dam Lake 23 metric characters including standard length (SL), fork length (FL) and total length (TL) and body weight were measured (Table 1). The TL and weight (min-max) of the fish were 6.40 – 10.20 cm and 1.50 – 7.31 g, respectively.

Table 1. Metric characters of A. boyeri specimens.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Min (cm)</th>
<th>Max (cm)</th>
<th>Average</th>
<th>SD</th>
<th>CI</th>
<th>Margin of error</th>
<th>Upper bound</th>
<th>Lower bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Standard Length</td>
<td>5.50</td>
<td>8.70</td>
<td>7.18</td>
<td>0.925</td>
<td>0.331</td>
<td>0.056</td>
<td>7.511</td>
<td>6.849</td>
</tr>
<tr>
<td>2 Fork Length</td>
<td>5.90</td>
<td>9.80</td>
<td>7.64</td>
<td>1.040</td>
<td>0.372</td>
<td>0.071</td>
<td>8.012</td>
<td>7.268</td>
</tr>
<tr>
<td>3 Total Length</td>
<td>6.40</td>
<td>10.20</td>
<td>8.25</td>
<td>1.071</td>
<td>0.383</td>
<td>0.075</td>
<td>8.637</td>
<td>7.870</td>
</tr>
<tr>
<td>4 Preorbital distance</td>
<td>0.40</td>
<td>0.80</td>
<td>0.56</td>
<td>0.094</td>
<td>0.033</td>
<td>0.001</td>
<td>0.590</td>
<td>0.523</td>
</tr>
<tr>
<td>5 Eye diameter</td>
<td>0.40</td>
<td>0.70</td>
<td>0.54</td>
<td>0.073</td>
<td>0.026</td>
<td>0.000</td>
<td>0.569</td>
<td>0.517</td>
</tr>
<tr>
<td>6 Interorbital distance</td>
<td>0.40</td>
<td>0.80</td>
<td>0.60</td>
<td>0.116</td>
<td>0.041</td>
<td>0.001</td>
<td>0.645</td>
<td>0.562</td>
</tr>
<tr>
<td>7 Head length</td>
<td>0.90</td>
<td>2.00</td>
<td>1.56</td>
<td>0.257</td>
<td>0.092</td>
<td>0.004</td>
<td>1.655</td>
<td>1.472</td>
</tr>
<tr>
<td>8 Head width</td>
<td>0.60</td>
<td>1.10</td>
<td>0.80</td>
<td>0.131</td>
<td>0.047</td>
<td>0.001</td>
<td>0.847</td>
<td>0.753</td>
</tr>
<tr>
<td>9 Gill cover length</td>
<td>0.50</td>
<td>1.80</td>
<td>0.74</td>
<td>0.299</td>
<td>0.107</td>
<td>0.006</td>
<td>0.844</td>
<td>0.630</td>
</tr>
<tr>
<td>10 Dorsal fin I nose point</td>
<td>0.30</td>
<td>4.10</td>
<td>3.18</td>
<td>0.667</td>
<td>0.239</td>
<td>0.029</td>
<td>3.418</td>
<td>2.941</td>
</tr>
<tr>
<td>11 Dorsal fin II nose point</td>
<td>0.50</td>
<td>6.10</td>
<td>4.76</td>
<td>1.021</td>
<td>0.365</td>
<td>0.068</td>
<td>5.129</td>
<td>4.398</td>
</tr>
<tr>
<td>12 Preanal distance</td>
<td>0.70</td>
<td>6.30</td>
<td>4.60</td>
<td>1.002</td>
<td>0.359</td>
<td>0.066</td>
<td>4.955</td>
<td>4.238</td>
</tr>
<tr>
<td>13 Prepectoral distance</td>
<td>0.30</td>
<td>2.20</td>
<td>1.72</td>
<td>0.407</td>
<td>0.145</td>
<td>0.011</td>
<td>1.869</td>
<td>1.578</td>
</tr>
<tr>
<td>14 Preventral distance</td>
<td>0.30</td>
<td>3.60</td>
<td>2.70</td>
<td>0.623</td>
<td>0.223</td>
<td>0.025</td>
<td>2.923</td>
<td>2.477</td>
</tr>
<tr>
<td>15 Dorsal fin I base length</td>
<td>0.20</td>
<td>1.20</td>
<td>0.47</td>
<td>0.186</td>
<td>0.067</td>
<td>0.002</td>
<td>0.533</td>
<td>0.400</td>
</tr>
<tr>
<td>16 Dorsal fin II base length</td>
<td>0.40</td>
<td>1.20</td>
<td>0.89</td>
<td>0.190</td>
<td>0.068</td>
<td>0.002</td>
<td>0.958</td>
<td>0.822</td>
</tr>
<tr>
<td>17 Anal fin base length</td>
<td>0.60</td>
<td>1.50</td>
<td>1.03</td>
<td>0.222</td>
<td>0.079</td>
<td>0.003</td>
<td>1.109</td>
<td>0.951</td>
</tr>
<tr>
<td>18 Pectoral fin base length</td>
<td>0.20</td>
<td>0.50</td>
<td>0.32</td>
<td>0.068</td>
<td>0.024</td>
<td>0.000</td>
<td>0.348</td>
<td>0.299</td>
</tr>
<tr>
<td>19 Ventral fin base length</td>
<td>0.10</td>
<td>0.60</td>
<td>0.22</td>
<td>0.146</td>
<td>0.052</td>
<td>0.001</td>
<td>0.269</td>
<td>0.164</td>
</tr>
<tr>
<td>20 Maximum body height</td>
<td>0.90</td>
<td>2.00</td>
<td>1.39</td>
<td>0.234</td>
<td>0.084</td>
<td>0.004</td>
<td>1.474</td>
<td>1.306</td>
</tr>
<tr>
<td>21 Caudal peduncle height</td>
<td>0.20</td>
<td>0.70</td>
<td>0.48</td>
<td>0.110</td>
<td>0.039</td>
<td>0.001</td>
<td>0.519</td>
<td>0.441</td>
</tr>
<tr>
<td>22 Body width</td>
<td>0.50</td>
<td>1.30</td>
<td>0.83</td>
<td>0.187</td>
<td>0.067</td>
<td>0.002</td>
<td>0.894</td>
<td>0.760</td>
</tr>
<tr>
<td>23 Caudal peduncle width</td>
<td>0.10</td>
<td>0.30</td>
<td>0.19</td>
<td>0.058</td>
<td>0.021</td>
<td>0.000</td>
<td>0.214</td>
<td>0.172</td>
</tr>
<tr>
<td>24 Body Weight (g)</td>
<td>1.50</td>
<td>7.31</td>
<td>3.94</td>
<td>1.545</td>
<td>0.553</td>
<td>0.156</td>
<td>4.495</td>
<td>3.389</td>
</tr>
</tbody>
</table>

Bartulovic et al. (2004) in Mala Neretva River, Croatia (TL=3.1 - 11.6 cm); Tarkan et al. (2006) in Küçükçekmece Lake (TL=3.9-11.1 cm); Özeren (2009) in İznil Lake (TL= 8.0 – 11.5 cm, W= 0.001 - 11.0 g); Çetinkaya et al. (2011) in İznil Lake (FL=2.0 - 10.6 cm, W= 0.06 - 10.5 g); İlhan & Sarı (2015) in Marmara Lake (TL= 3.70 - 8.70 cm).
W= 0.40 - 5.40 g); Saç et al. (2016) in Büyükçekmece Reservoir (SL= 3.1 - 6.1 cm, W= 0.295 - 2.360 g); Gençoğlu & Ekmekçi (2016) in Hirfanlı Dam Lake (TL= 5.76 - 115.65 mm, W= 0.01 - 10.48 g); Ünlü et al. (2017) in Devegeçidi Dam Lake (TL= 43.3 - 55.1 mm, W= 0.7 – 8.0 g); Çevik et al. (2018) in Seyhan Reservoir (FL= 66 – 92 mm, W=2.1-5.9 g); Partal et al (2019) in Bayramiç Reservoir (TL= 2.4 - 8.2 cm, W= 0.06 – 4.31 g) are reported some features in the literature.

Data distribution and prediction performances of ANNs trained and tested with twenty-three morphometric characters (without weight data) and weight variables in Yamula Dam Lake by using the big-scale sand smelt were shown in Fig. 4.

Fig. 4. Prediction performances of ANNs and data distribution.

The ANNs model results were found for fish caught from Yamula Dam Lake. It can be seen that ANNs give good results according to MAPE and $R^2$ (Table 2). The MAPE benchmark refers to forecast errors as a percentage, and can therefore negate the disadvantages that may arise when correlating models developed for examines with different values. MAPE results are considered to be very good when performed between 0% and 10% (Witt & Witt, 1992).
Atherina boyeri has a large adaptation talent and usually inhabits at the unstable conditions of seas, lagoons and lakes such as temperature, salinity, turbidity, and currents (Bartulovic et al., 2004; Çetinkaya et al., 2011).

It has reported that morphometric characters may vary not only in populations but also in regions (Chan, 2001). There are differences in the morphological characteristics and morphological diversity at the regional level of the population (Francisco et al., 2006).

Table 2. Results with LWR and ANNs.

<table>
<thead>
<tr>
<th>Sex</th>
<th>All</th>
<th>Length</th>
<th>Weight</th>
<th>MAPE (%)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual Data</td>
<td>ANNs Calculate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yamula Dam Lake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weight</td>
<td>Weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.64</td>
<td>3.94</td>
<td>3.79</td>
<td>3.807</td>
</tr>
</tbody>
</table>

Table 3. Some morphometric measurements of A. boyeri in literature.

<table>
<thead>
<tr>
<th>Metric</th>
<th>This Study Yamaula Dam Lake</th>
<th>Benzer, 2019 Hüfsta Dam Lake</th>
<th>Çevik et al., 2018 Seyhan Dam Reservoir</th>
<th>Benzer, 2018 Süreyyabey Dam Lake</th>
<th>Ünlü et al., 2017 Devegeçit Dam Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD (Range)</td>
<td>Mean±SD (Range)</td>
<td>Mean±SD (Range)</td>
<td>Mean±SD (Range)</td>
<td>Mean±SD (Range)</td>
</tr>
<tr>
<td>TL</td>
<td>8.25±1.071 (6.40-10.20)</td>
<td>79.26±4.30 (65-86)</td>
<td>83.8±9.50 (72.1-100.1)</td>
<td>66.1±5.40 (58-78)</td>
<td>47.0±4.2 (43.3-59.9)</td>
</tr>
<tr>
<td>FL</td>
<td>7.64±1.04 (5.90-9.80)</td>
<td>74.0±4.24 (61-81)</td>
<td>77.7±8.58 (66.0-92)</td>
<td>60.65±5.32 (49-73)</td>
<td>44.1±3.6 (40.3-55.1)</td>
</tr>
<tr>
<td>SL</td>
<td>7.18±0.93 (5.50-8.70)</td>
<td>69.0±4.11 (56-78)</td>
<td>72.1±7.70 (61.0-85)</td>
<td>56.93±5.50 (41-68)</td>
<td>40.7±3.4 (37.7-50.9)</td>
</tr>
<tr>
<td>W</td>
<td>3.94±1.54 (1.5-7.31)</td>
<td>3.09±0.62 (1.53-4.13)</td>
<td>3.6±1.11 (2.1-5.90)</td>
<td>1.95±0.60 (0.90-3.57)</td>
<td>2.9±3.2 (0.7-8)</td>
</tr>
<tr>
<td>HL</td>
<td>1.56±0.25 (0.9-2.0)</td>
<td>14.88±1.81 (10-19)</td>
<td>12.9±1.64 (10-16.0)</td>
<td>11.89±2.19 (8-16)</td>
<td>9.6±1.1 (8.4-12.9)</td>
</tr>
<tr>
<td>ED</td>
<td>0.55±0.07 (04.0.7)</td>
<td>5.02±0.56 (4-6)</td>
<td>3.4±0.58 (2.8-4.50)</td>
<td>4.41±0.68 (3-6)</td>
<td>3.5±0.5 (3.0-4.9)</td>
</tr>
<tr>
<td>IO</td>
<td>0.60±0.11 (04-0.8)</td>
<td>4.61±0.81 (3-6)</td>
<td>2.6±0.43 (2.1-3.10)</td>
<td>3.69±0.81 (3-7)</td>
<td>3.2±0.2 (2.6-3.4)</td>
</tr>
<tr>
<td>POL</td>
<td>0.56±0.09 (04-0.8)</td>
<td>5.01±0.69 (3-7)</td>
<td>3.9±0.82 (2.1-5.50)</td>
<td>3.84±0.89 (2-6)</td>
<td>3.5±0.4 (3.0-4.6)</td>
</tr>
</tbody>
</table>

* (cm); ** (mm); W (g).
Many morphometric characters of *A. boyeri* from the Yamula Dam Lake are different with those given for the İznik Lake (Altun, 1999), İzmir Basin (Taşkavak *et al.*, 2012) Eğirdir Lake (Bostanci *et al.*, 2014), Devegeçidi Dam Lake (Ünlü *et al.*, 2017), Seyhan Dam Lake (Çevik *et al.*, 2018), Süreyyabey Dam Lake (Benzer, 2018) and Hirfanlı Dam Lake (Benzer, 2019). Such differences between populations could possibly explained by the variable morphometries of this polymorphic species in relation to physical and chemical variables characteristic of different environments (Antonucci *et al.*, 2012) or errors by different workers taking the measurements (Palmer *et al.*, 1979).

Total length average of *Atherina boyeri* individuals in Yamula Dam Lake was lower than Seyhan Dam Lake (Çevik *et al.*, 2018) values; Hirfanlı Dam Lake (Benzer, 2019), Süreyya Bay Dam Lake (Benzer, 2018), Devegeçidi Dam Lake (Ünlü *et al.*, 2017) was higher than values (Table 3). It was determined that HL, ED, IO, POL mean values of Yamula Dam Lake were higher than the values in the literature (Table 3).

**CONCLUSION**

In the research describes the area where reveals the biometric data of *Atherina boyeri* population. In this study, morphometric properties of *Atherina boyeri* were determined. It is considered that the data obtained in this study will also contribute to future studies.

Finally, it is recommended that the big-scale sand smelt population should be carefully monitored in the future to ensure sustainable economic yield by other mathematical approaches in Yamula Dam Lake and other inland water resources.

**REFERENCES**


