An assessment of embryonic mortality stages in Chukar partridge (Alectoris chukar) by means of classification tree method

Eine Bewertung der Zeitpunkte embryonaler Sterblichkeit beim Chukarhuhn (Alectoris chukar) anhand des Klassifikationsbaum-Verfahrens

K. Karabağ1, M. Mendeş2, S. Alkan3 and M.S. Balcioğlu3


Introduction

The Chukar partridge (Alectoris chukar) is a wild bird in poultry. Its natural populations significantly diminished in recent years due to excessive hunting and destruction of natural habitats. However, partridge breeding for hunting and egg and meat production gets more and more common (ÖZBEY and ESEN, 2007). The egg quality characteristics (NARUSHIN and ROMANOV, 2002; KHIRSHID et al., 2004) and embryonic mortality (SCOTT and MACKENZIE, 1993; MROZ et al., 2007) have been well documented for domestic fowl. Egg fertility and embryonic mortality were found affecting hatchability (FAIRCHILD et al., 2002). Egg weight, shell weight, shell thickness and fertility, which are physical characteristics of eggs, also play an important role in the processes of embryo development and hatching success in poultry (NARUSHIN and ROMANOV, 2002; and KHIRSHID et al., 2004). However, there is little information in literature regarding egg characteristic parameters and embryo mortality for partridge (ÖZBEY and ESEN, 2007; KİRİKÇİ et al., 2007).

Many possible (genetic and environmental) factors and complex interactions between them can affect egg characteristics and embryo mortality in partridge. Traditional statistical methods can be cumbersome to analyze this kind of data sets. Classification tree method (CTM) is a potentially powerful tool to predict membership of cases in the classes of a categorical dependent variable from their measurements on one or more predictor variables. CTM will be a good choice, especially when data set is large, relations between variables are non-linear and when independent variables are mixed (both continuous and categorical). CTM is also structurally very simple and easy to visualize. CTM is a binary decision tree. The tree is constructed by splitting the whole data into nodes or sub-groups based on yes/no answers about the values of the predictors. Each split is based on a single predictor variable. On the other hand, some of the predictors may be used more than one time while others may not be used at all. The rule generated at each step maximizes the class purity within each of the two resulting subsets. Each subset is split further based on entirely different relationships.

That is, CTM begins with root node that contains all of the observations in the sample and then branch into mutually exclusive child nodes (sub-groups). Observations of sub-groups are more homogeneous than in the root node. This process goes on until the index of homogeneity meets its requirements (BREIMAN et al., 1984; BREIMAN et al., 2003; BEVILAQUA et al., 2003; TEMEL et al., 2005).

The use of classification tree is not widespread in the fields of agriculture but widely used in applied fields as biology (SCULL et al., 2005; MASSEY et al., 2008) and medicine (GARZOTTO et al., 2005; JAZBEC et al., 2007). Therefore, the present study was performed to determine the embryonic mortality stages related to external egg characteristics in Chukar partridge using CTM.

Materials and Methods

The forty week-old parent Chukars were housed in individual cages in the Agriculture Faculty’s Research and Application Farm of Akdeniz University. Two females and one male were placed into each cage at random. An ad libitum ration was provided (Table 1) and water was supplied via automatic water cups. The whole experimental eggs collected daily during twenty days were numbered and weighted by digital balance (0.010 gram sensitive). A digital caliper was used to measure the maximum breadth (0.001 mm accuracy on two sides in the equatorial region) and length of each egg. The eggs were stored in two parties for 10 days prior to being set in the incubator at a temperature of 15.0–18.0°C and approximately relative humidity of 65.0–70.0%. Each egg was put into an individual hatching cell on the trays. The setter and hatcher temperature and relative humidity were maintained at 37.7°C, 37.2°C, and 60.0%, 75.0%, respectively. The incubation period is twenty-four days for partridges, therefore, the eggs were transferred to the hatchery trays at the end of twentieth day of incubation.

A total of 1,193 eggs from 90 female Chukars were placed into the incubator. The eggs that failed to hatch were counted, broken, and visually evaluated to determine the stage of embryonic mortality after chicks had hatched. All dead embryos were classified as early embryonic mortality (EEM), medium embryonic mortality (MEM) and late embryonic mortality (LEM) as defined by the first 10d, second 10d and last 4d of incubation (LOURENS et al., 2005; MROZ et al., 2007). Then, 193 intact egg shells were randomly taken from fertilized eggs. Egg shell thickness of these eggs was measured using a micrometer capable of 0.010 mm accuracy on two sides in the equatorial region (EST), blunt (BST) and pointed (PST) edges without shell

1 University of Rize, Vocational Academy of Pazar, Rize, Turkey
2 Çanakkale Onsekiz Mart University, Faculty of Agriculture, Dept. of Animal Science, Çanakkale, Turkey
3 University of Akdeniz, Faculty of Agriculture, Dept. of Animal Science, Antalya, Turkey
Results and Discussion

The means of the external egg traits belonging to embryonic mortality stages are presented in Table 2. Several researchers reported that egg weights (EW) varied between 21.1 and 23.9 g for Graeca partridge (ÖZBEY and ESEN, 2007; KIRIKÇI et al., 2007; ÇAGLAYAN et al., 2009), and between 19.2 and 21.4 g for Chukar partridge (ÇETİN et al., 1997; SONG et al., 2000 and ALKAN et al., 2007), which were consistent with our result (21.9 g).

ALKAN et al. (2007) reported that egg width and egg length were 30.9 mm and 41.5 mm, respectively. These values were similar to our findings. Several researchers reported that the shell weight ranged between 2.23 and 2.86 g (ÖZBEY and ESEN, 2007; KIRIKÇI et al., 2007, ÇAGLAYAN et al., 2009). These values were higher than present finding (1.56 g). Besides, shell thickness was found as 23.9 µm in this study, which was similar to rock partridge (TLİKİ and SAATCI, 2004; ÖZBEY and ESEN, 2007, KIRIKÇI et al., 2007), but lower than for red-legged partridge (CASTILLA et al., 2009). The shell ratio (7.22%) in this study was lower than that reported by ÇAGLAYAN et al. (2009; 10.9%) and by TLİKİ and SAATCI (2004; 11.7% – 13.6%).

In the 193 eggs where shell thickness was measured number of embryonic mortality amounted to 45.0. The ratios of the early embryonic mortality (EEM), medium embryonic mortality (MEM) and late embryonic mortality (LEM) were calculated for the 45 eggs including dead embryos as 37.8, 17.8 and 44.4%, and for the 193 fertile eggs as 8.81, 4.14 and 10.36%, respectively, which indicated that the ratio of LEM was higher than for EEM and MEM in this study. Embryonic mortality was high or increased at some stages of incubation. Late embryonic mortality in the hatching unit increases by 3.00 to 5.60% along with an increase in egg weight and egg quality deterioration (MROZ et al., 2007). However, ALKAN et al. (2008) reported total embryonic mortality as 9.11% in Chukar partridge, which was lower than our result (23.3%).

The optimum classification tree is given in Figure 1. The classification tree was formed in 8 nodes. Node 0 contained the proportion of embryonic mortality stages. Examining Figure 1 it is possible to associate external egg traits (EW, EV, BST and AST) with embryonic mortality stages (EEM, MEM, and LEM). The embryonic mortality stages were affected primarily by egg weight (EW), egg volume (EV), blunt-edge shell thickness (BST) and average shell thickness (AST). EW was root terminal node and was divided into two arms (Node 1 and Node 2). Embryonic
Table 2. Means ± standard errors of external properties of eggs belong to embryonic mortality stages (N ± SE)

<table>
<thead>
<tr>
<th>N</th>
<th>EW (g)</th>
<th>EB (cm)</th>
<th>EL (cm)</th>
<th>BST (µ)</th>
<th>PST (µ)</th>
<th>EST (µ)</th>
<th>AST (µ)</th>
<th>SW (g)</th>
<th>SR (%)</th>
<th>EV (cm³)</th>
<th>SSA (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEM</td>
<td>17</td>
<td>21.7</td>
<td>3.12</td>
<td>4.19</td>
<td>23.7</td>
<td>24.5</td>
<td>25.0</td>
<td>24.5</td>
<td>1.57</td>
<td>2.70</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>± 1.20</td>
<td>± 0.08</td>
<td>± 0.10</td>
<td>± 2.41</td>
<td>± 2.63</td>
<td>± 2.27</td>
<td>± 1.99</td>
<td>± 0.10</td>
<td>± 0.10</td>
<td>± 1.69</td>
<td>± 1.35</td>
</tr>
<tr>
<td>MEM</td>
<td>8</td>
<td>21.6</td>
<td>3.13</td>
<td>4.14</td>
<td>22.4</td>
<td>22.3</td>
<td>23.6</td>
<td>23.0</td>
<td>1.56</td>
<td>2.71</td>
<td>26.9</td>
</tr>
<tr>
<td></td>
<td>± 1.52</td>
<td>± 0.08</td>
<td>± 0.11</td>
<td>± 2.87</td>
<td>± 2.59</td>
<td>± 2.02</td>
<td>± 2.16</td>
<td>± 0.12</td>
<td>± 0.13</td>
<td>± 1.95</td>
<td>± 1.72</td>
</tr>
<tr>
<td>LEM</td>
<td>20</td>
<td>22.3</td>
<td>3.15</td>
<td>4.18</td>
<td>23.3</td>
<td>24.4</td>
<td>23.9</td>
<td>23.9</td>
<td>1.62</td>
<td>2.66</td>
<td>27.6</td>
</tr>
<tr>
<td></td>
<td>± 1.68</td>
<td>± 0.10</td>
<td>± 0.14</td>
<td>± 2.80</td>
<td>± 2.80</td>
<td>± 2.32</td>
<td>± 2.00</td>
<td>± 0.14</td>
<td>± 0.14</td>
<td>± 2.28</td>
<td>± 1.91</td>
</tr>
<tr>
<td>means</td>
<td>45</td>
<td>21.9</td>
<td>3.14</td>
<td>4.18</td>
<td>23.3</td>
<td>24.1</td>
<td>24.2</td>
<td>24.0</td>
<td>1.59</td>
<td>2.69</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td>± 1.48</td>
<td>± 0.09</td>
<td>± 0.12</td>
<td>± 2.64</td>
<td>± 2.76</td>
<td>± 2.28</td>
<td>± 2.05</td>
<td>± 0.12</td>
<td>± 0.12</td>
<td>± 1.99</td>
<td>± 1.68</td>
</tr>
</tbody>
</table>


Figure 1. Classification tree of external egg traits that influence the embryonic mortality stages (EW: egg weight, EV: egg volume, BST: blunt-edge shell thickness, AST: average shell thickness; category 2.000: EEM, 3.000: MEM, 4.000: LEM)

Klassifikationsbaum der Schalenmerkmale mit Einfluss auf die embryonale Sterblichkeit (EW: Eigengewicht, EV: Eivolumen, BST: Schalen dicke am stumpfen Ende, AST: durchschnittliche Schalendicke; Kategorien: 2.000 – EEM, 3.000 – MEM, 4.000 – LEM)
mortality stages were influenced by EV when EW was less than 22.1 g (Node 1) and by BST when EW was greater than 22.1 g (Node 2). According to Node 1, when EW was less than 22.1 g, EEM (59.1%) was found to be higher than MEM (18.2%) and LEM (22.7%). But, when EW was higher than 22.1 g (Node 2), LEM (65.2%) was much higher than EEM (17.4%) and MEM (17.4%). When EW and EV were less than 22.1 g and 25.1 ml, respectively, LEM was probably 66.7%, but EEM did not occur (Node 3). On the other hand, EEM was about 81.2% (Node 4) when EW was less than 22.1 g and EV was higher than 25.1. When EW and BST were higher than 22.1 g and 22.3 µm (Node 6), respectively, LEM and MEM amounted to 80.0% and 6.70%. Embryonic mortality stages were influenced by AST when BST was less than 22.3 µm (Node 5). EEM did not occur, but MEM occurred about 75% when BST was less than 24.3 µm. Also, when AST was higher than 22.3 µm EEM and LEM occurred but MEM did not.

By CTM we estimated with an accuracy of 75.6% that EW, EV, BST, and AST primarily affected embryonic mortality stages (EEM, MEM, LEM) during incubation in this study.

CASTILLA et al. (2009) reported that egg weight and shell thickness had no significant effect on embryonic mortality in fertilized eggs. While, early embryonic mortality was found to be negatively correlated with egg weight and shell thickness, late embryonic mortality was found to be positively correlated with egg weight and shell thickness in Japanese quail by KHURSHID et al. (2004). Also, EL-SHEIKH (2007) reported that malformation and malposition of the embryonic mortality were affected by egg weight. However, the success of embryonic development in poultry eggs has been related to the eggshell characteristic (TÜRKYILMAZ et al., 2005). TSARENKO (1988) noted that hatchability of thick-shelled eggs was higher than for thin-shelled eggs. NARUSHIN and ROMANOV (2002) presented that extremely thick or thin shells resulted in increased embryonic mortality. Also, TÜRKYILMAZ et al. (2005) reported that higher LEM for thinnest BST.

Results obtained from this study were similar to some results reported by KHURSHID et al. (2004), TSARENKO (1988), NARUSHIN and ROMANOV (2002), TÜRKYILMAZ et al. (2005), but were different from results reported by CASTILLA et al. (2009). The differences between this study and the other studies in respect to findings could be caused by types of studies, experimental conditions, differences in the number of animals and especially used different statistical techniques.

Classification tree method is a powerful technique with significant potential. The application in this study to present highly detailed information regarding the causes of embryonic mortality stages visually. The replication of the study with a larger sample will allow validating the technique. Finally, the results of this study showed that CTM could be used in the fields of agriculture.

According to CTM, the embryonic mortality stages were affected by egg weight (EW), egg volume (EV), blunt-edge shell thickness (BST) and average shell thickness (AST). EW appeared as root terminal node at the classification tree. Embryonic mortality stages were influenced by EV when EW was less than 22.1 g and by BST when EW was greater than 22.1 g. EEM occurred more often than MEM and LEM when EW was less than 22.1 g. However, when EW was higher than 22.1 g, LEM was higher than EEM and MEM. When EW and BST were higher than 22.1 g and 22.3 µm, respectively, LEM was about 80.0%. EEM was about 81.2% when EW was less than 22.1 g and EV was higher than 25.1. MEM occurred about 75% when BST was less than 24.3 µm. CTM estimated with an accuracy of 75.6% that EW, EV, BST, and AST primarily affected embryonic mortality stages. Finally, the results of this study showed that this method could be used in the fields of agriculture.

Key words
Chukar partridge, classification tree, incubation, egg shell quality, embryonic mortality

Zusammenfassung
Eine Bewertung der Zeitpunkte embryonaler Sterblichkeit beim Chukarhuhn (Alectoris chukar) anhand des Klassifikationsbaum-Verfahrens


Die Ergebnisse des CMT belegen, dass die Zeitpunkte der embryonalen Sterblichkeit (früh – EEM, mittel – MEM, spät – LEM) in erster Linie durch das Eigewicht, das Eivolumen, die Schalendicke am stumpfen Ende und die durchschnittliche Schalendicke beeinflusst wurden. Das Eigewicht erwies sich dabei als Ausgangsknotenpunkt des CMT. Die Zeitpunkte embryonaler Sterblichkeit wurden durch das Eivolumen beeinflusst, wenn das Eigewicht kleiner 22.1 g war, und durch die Schalendicke am stumpfen Ende, wenn das Eigewicht größer 22.1 g war. Bei Eiern mit einem Gewicht von weniger als 22.1 g wurde häufiger frühe Sterblichkeit (EEM) als mittlere (MEM) oder späte (LEM) beobachtet. Bei Eiern mit einem Gewicht von mehr als 22.1 g trat späte Mortalität (LEM) häufiger auf als frühe oder mittlere. Die späte Mortalität betrug etwa 80% für Eier mit einem Gewicht von mehr als 22.1 g und einer Schalendicke am stumpfen Ende von mehr als 22.3 µm. Die frühe Mortalität lag bei 81,2% für Eier mit weniger als 22.1 g und einem Eivolumen von mehr als 25,1 ml. Bei einer durchschnittlichen Schalendicke von mehr als 22.3 µm trat nur frühe und späte Mortalität auf. Das CMT hat mit einer Sicherheit von 75,6% belegt, dass Eigewicht, Eivolumen, Schalendicke am stumpfen Ende und durchschnittliche Schalendicke den größten Einfluss auf die Zeitpunkte der embryonalen Sterblichkeit haben. Die Ergebnisse haben ferner gezeigt, dass dieses Verfahren auch in Gebieten der Tierwissenschaften angewendet werden kann.

Summary
Classification tree method is a potentially powerful tool to predict membership of cases in the classes of a categorical dependent variable. The use of classification tree is not widespread in the fields of agriculture. Egg weight, shell thickness, shell weight, shell ratio, egg width, egg length, egg volume, shell surface area were chosen for investigating of their influence on embryonic mortality stages in fertilized eggs of Chukar partridge. All measured and calculated egg parameters were analyzed by classification tree method in this study.
Stichworte

Chukarhuhn, Klassifikationsbaum, Brut, Eischalenqualität, Embryonalsterblichkeit

References


LEWIS, R.J., M.D., Ph.D., 2000: An Introduction to Classification and Regression Tree (CART) Analysis. Department of Emergency Medicine Harbor-UCLA Medical Center Torrance, California.


Correspondence: Assist. Prof. Dr. Kemal Karabag, University of Rize Vocational Academy of Pazar, 55300 Rize, Turkey; E-mail: kemal.karabag@rize.edu.tr

Arch.Geflügelk. 4/2010