Usability of CART algorithm for determining egg quality characteristics influencing fertility in the eggs of Japanese quail

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ABSTRACT - The objective of this study was to determine the effects of egg quality characteristics (egg weight, egg width, egg height, and shape index) on fertility of eggs of Japanese quail with different colored feathers (yellow, white, grizzled, and normal), which are of economic importance for poultry production. For this purpose, 383 eggs of Japanese quail with various feather colors were used. In the study, usability of classification and regression tree (CART) data-mining algorithm as a classification tree method is necessary for poultry breeders to define proper cut-off values of egg quality characteristics that ensure Japanese quail eggs at good quality in fertility. Fertility as the dependent variable in the study was examined as a binary trait (fertile and infertile) and all the egg quality traits accepted as explanatory variables were continuous variables. Feather color was also included as a nominal categorical explanatory variable. The classification tree results showed that the highest fertility ratio of 90.9% was obtained from the eggs of Japanese quail of white, grizzled, and normal feather colors with 10.425 g ≥ egg weight, 24.565 mm ≥ egg width, or the fertility ratio of 88.2% of the eggs was observed with 10.425 g ≤ egg weight and 25.605 mm ≥ egg width. Consequently, usability of the tree-based CART algorithm is important in practice for properly establishing fertilized eggs, depending on feather color types of Japanese quail.

Key Words: data mining algorithm, quail egg, hatchability

Introduction

Japanese quail (*Coturnix coturnix japonica*) is one of the most appropriate animal materials for poultry breeding studies (Alkan et al., 2008). Altan et al. (1998) evaluated the effects of selection in Japanese quail. Turkmut et al. (1999) reported that egg weight, albumen index, and yolk index positively changed during selection of Japanese quail. In quail production, hatchability and fertility are momentous parameters affected by sex ratio, genetic factors, egg characteristics, and parental live body weight and age (Ayasan, 2013). The most determining factors affecting the fertility are season, stock density, and selection taking place in the scope of quail breeding (Kucukonder et al., 2014). Sari et al. (2010) investigated the influence of egg weight, shape index, and parental age on hatchability traits and survival rate for Japanese quail. Storage time and temperature of eggs in managerial condition were reported to be environmental factors affecting fertility trait with low heritability in poultry science (Ozdemir and Inci, 2012; Celik et al., 2014; Kucukonder et al., 2014). In the determination of optimal conditions for quail production, powerful statistical approaches help breeders to perfectly establish some decisive factors and egg traits on fertility and hatchability. Herewith, as of lately, few studies on data mining algorithms have been conducted for deciding factors and egg characteristics affecting hatchability and fertility in poultry production (Karabag et al., 2010; Kucukonder et al., 2014; Uckardes et al., 2014).

Classification and regression tree (CART) practiced for nominal, ordinal, and continuous variables is the data-mining algorithm used for constructing the decision tree as a good alternative to discriminant analysis and particularly logistic regression analysis (Camdeviren et al., 2007). The tree-based CART algorithm without finding any assumption necessary for explanatory variables is structured by a categorical dependent variable and both categorical and continuous explanatory variables for large data sets (Karabag et al., 2010). The algorithm produces binary nodes by dividing each node into two child nodes, recursively until homogeneous subgroups are obtained in the tree diagram. With the development of computer technology at the present time, statistical analysis of the algorithm is feasible in SAS (Statistical Analysis System), SPSS (Statistical Package for Social Sciences) (Ali et al., 2015), and STATISTICA (Camdeviren et al., 2007; Nisbet et al., 2009; Zaborski et al., 2014) softwares.

In the classification problems, usage of various data-mining algorithms for animal science has recently been recorded for beef cattle (Grzesiak et al., 2014; Kucukonder et al., 2015), dairy cattle (Grzesiak et al., 2010; Grzesiak et al., 2011; Zaborski et al., 2014; Bayram et al., 2015), and fisheries science (Topal et al., 2010). Yet, application of data-mining algorithms for poultry science has been scarce for Japanese quail (Kucukonder et al., 2014; Uckardes et al., 2014) and Chukar partridge (*Alectoris chukar*) (Karabag et al., 2010). Among the researchers, Uckardes et al. (2014) preferred CHAID (chi-square automatic interaction detector) data-mining algorithm to identify the effects of genotype, season, and cage stocking on fertility for Japanese quail, while Kucukonder et al. (2014) described the influence of season, selection, and cage stocking on fertility of Japanese quail with several classification algorithms. However, we have not yet found the published article on establishing the effect of some egg quality characteristics on fertility for Japanese quail eggs having economic importance for poultry production. The goal of the study was to establish egg quality traits (egg weight, egg width, egg height, and shape index) effecting fertility with the aid of CART data-mining algorithm. It is necessary for quail breeders to recognize proper cut-off values of egg quality characteristics that guarantee fertilized Japanese quail eggs at good quality.

Material and Methods

The animal material of the current study was composed of 450 quail eggs laid by Japanese quail breeders with four different feather colors (yellow, white, grizzled, and normal) reared in Bingol Province, Turkey. They were housed on six floors, with 40 quail/floor for a time period of seven weeks. All the groups were fed the ration of 23% crude protein (CP) and 3100 kcal/kg metabolizable energy during the first week. At subsequent weeks, they were fed the ration of 20% CP and 3250 kcal/kg metabolizable energy. Quail eggs collected from all the color groups were measured as for weight, width, height, and shape index (egg width ×100/egg height) and then placed in egg incubator. At the end of incubation time of 17 days, hatchability and early embryonic mortality were determined for 383 fertilized eggs, which were obtained from all hatching eggs.

We considered fertility as a binary dependent variable (coded as fertile and infertile). Independent continuous variables assessed in the study were egg quality characteristics, namely, egg weight, egg width, egg height, and shape index. In addition, feather color (yellow, white, grizzled, and normal) was used as a nominal independent variable.

The classification tree of the CART algorithm is recursively constructed by splitting a node (subset) into two child nodes (subsets) until homogenous subsets were produced. As a perfect alternative to logistic regression analysis, the tree-based CART algorithm detects significant explanatory variables affecting a dependent variable (Camdeviren et al., 2007).

We activated pruning option to remove redundant branches in the classification tree structure and regulated minimum numbers of quail in parent and child nodes as 10:5 to achieve classification performance at the highest level. V-fold cross validation is accepted as 10 in the CART algorithm. Accuracy of classification rate, sensitivity, and specificity were calculated as defined by Camdeviren et al. (2007).

In the study, CART analysis was conducted using the IBM SPSS 23 program.

Results

Descriptive statistics of egg characteristics are given in Table 1. Independent variables affecting fertility in Japanese quails were determined by CART algorithm. The tree structure gives some cut off-values, which can contribute to quail breeders in practice (Figure 1). An example of the cut-off values in the tree construction for egg weight was 10.425 g. Nodes coded as 3, 7, 8, 10, 11, and 12 were terminal nodes, since they proved satisfactory homogeneity. Accuracy classification, sensitivity, and specificity ratios were found as 74%, 95.2%, and 21%, respectively. Classification and regression tree algorithm predicted the fertilized eggs at the very high ratio of 95.2%, which may be important in practice for Japanese quail breeders. In further investigations, different variables can also be examined. In the normalized importance, the feather color, as an explanatory variable, contributed to the classification tree at the highest ratio (100%). It was followed by egg width (72.7%), egg height (46.7%), and egg weight (39.1%) (data not shown).

Node 0 had the fertility ratio of 71.3% in the tree diagram structure and was split by a discriminator, such as egg weight, into two child nodes coded as Node 1

Table 1 - Descriptive statistics for egg characteristics

Variable	N	Minimum	Maximum	Mean	Standard deviation
Egg weight (g)	383	8.59	16.97	11.69	1.14
Egg width (mm)	383	16.89	29.94	25.71	1.03
Egg height (mm)	383	25.82	40.51	33.33	1.64
Shape index	383	45.78	96.58	77.27	3.96

and Node 2, respectively. Node 1 is the group of eggs weighing 10.425 g or lighter and presented a fertility ratio of 54.5% from 44 eggs. When the classification tree was observed with the fertility ratio of 73.5%, Node 2 was the group of eggs whose weight was heavier than 10.425 g. In addition, it was remarked that 88.5% of all the eggs (n = 383) examined in the quail study were assigned to Node 2 (n = 339 eggs).

The first discriminator for Node 1, split into Node 3 (17 out of 383 eggs) and Node 4 (27 out of 383 eggs), respectively, was feather color as an explanatory variable. Node 3, with the fertility ratio of 29.4%, was the group of eggs whose weight was 10.425 g or lighter g in only yellow Japanese quails. Node 4 was the group of eggs whose weight was 10.425 g or lighter in Japanese quails with white, grizzled, and normal-colored feathers. Node 4, with
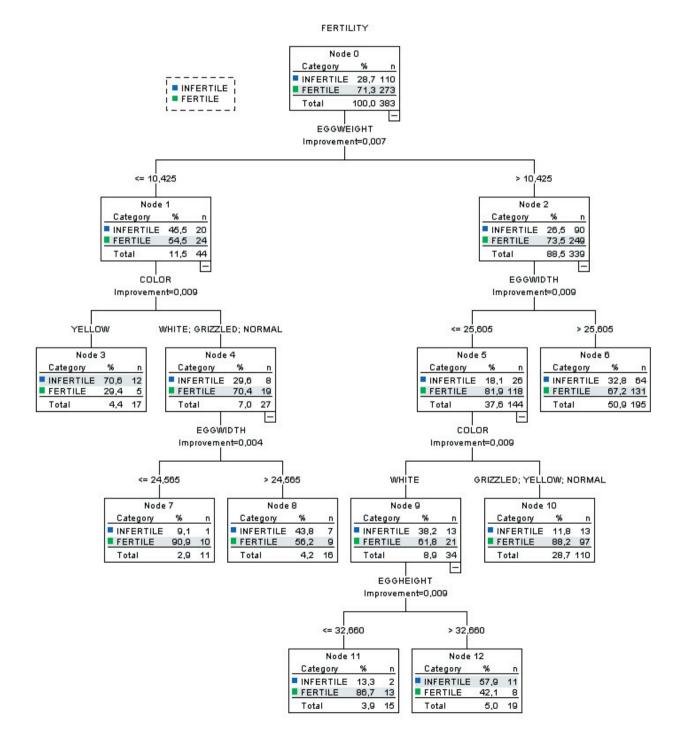

Figure 1 - The classification tree constructed by CART algorithm for fertility ratio.

the fertility ratio of 70.4%, was characterized by fertilized eggs, but Node 3 was characterized by unfertilized eggs. Nodes 7 and 8 were obtained from Node 4. Node 7 is the group of eggs whose weight was 10.425 g or lighter and whose width was 24.565 mm or narrower for Japanese quail with white, grizzled, and normal-colored feathers. The highest fertility ratio of 90.9% was obtained from the eggs in Node 7, which was obtained from Node 4 to characterize fertilized eggs very well. Node 8 was the group of eggs whose weight was 10.425 g or lighter and whose width was wider than 24.565 mm for white, grizzled, and normal-colored feathers. Node 2 was partitioned by egg width into two child nodes, Node 5 and Node 6, with the fertility ratios of 81.9% and 67.2%, respectively. The group named as Node 5 was of eggs whose weight was heavier than 10.425 g and whose width was 25.605 mm or narrower. As a terminal node, Node 6 was the group of eggs whose weight was heavier than 10.425 g and whose width was wider than 25.605 mm. Node 5 was divided into Node 9 and Node 10 according to color variable. Node 9, split by egg height into Node 11 and Node 12, was the group of eggs whose weight was heavier than 10.425 g and whose width was 25.605 mm or narrower in only white Japanese quails. It also provided the fertility ratio of 61.8%. Node 10, with the fertility ratio of 88.2%, was the group of eggs whose weight was heavier than 10.425 g and whose width was 25.605 mm or narrower for Japanese quails with grizzled, yellow, and normal feather colors. With the fertility ratio of 86.7%, Node 11 was the group of the white Japanese quail eggs whose egg weight was heavier than 10.425 g, whose egg width was 25.605 mm or narrower, and whose height was 32.660 mm or shorter. Node 12 was the group of the white Japanese quail eggs whose egg weight was heavier than 10.425 g, whose egg width was 25.605 mm or narrower, and whose height was taller than 32.660 mm.

Discussion

Dudusola (2013) reported better outcomes in hatchability (96.05% and 95.74%) and fertility (95% and 94%) at 22 weeks of age in comparison with 36 weeks of age for light and heavy egg weight groups of Japanese quail. Studying the influence of cage type and mating ratio on fertility of the eggs of Japanese quail, Narinc et al. (2013) noticed that the higher fertility ratios of 87.43 and 84.26% were estimated for the quails housed in individual cages and colony cages, respectively, compared with the overall fertility ratio in the study. The current general fertility ratio was lower than the ratio (82%) given as a result of selection studies in Uckardes et al. (2014). However, the authors

found the highest fertility ratios for control line (96.4%) and selection line (90.6%) at a stocking density of 240 cm^2/quail in autumn in the CHAID analysis. The highest fertility ratio (90.9%) was recorded for the eggs whose weight and width were 10.425 g or lighter and 24.565 mm or narrower in other colored quail except for yellow quails in the current data. However, the present highest ratio was slightly lower in comparison with the corresponding ratios informed by Uckardes et al. (2014). The main difference for fertility in literature may be attributed to usage of different factors (cage type, stocking density, mating ratio, and rearing system etc.), sample size, data-mining algorithms, and especially selection. The current visual data proved that the fertility ratio could vary based on feather color groups of Japanese quails when some nodes (Node 3 vs. Node 4 and Node 9 vs. Node 10) were examined. The color factor had much more contribution (100% normalized importance) in the construction of the classification tree diagram compared with other egg quality characteristics in the study. As in fattening performance, carcass, and egg quality characteristics (Inci et al., 2015), the fertility of the quail eggs should be considered in respect to different feather colors. The knowledge may be profitable for further relevant studies due to economic factors.

It was observed that 88.5% of the eggs obtained in the study were found heavier than 10.425 g (Node 2). Turkmut et al. (1999) reported that egg weight could be improved through selection program. Kucukonder et al. (2014) mentioned the importance of selection studies in fertility with major factors such as season and stock density. The present results are important for improving fertility and hatchability of Japanese quail.

Accuracy classification ratio (74%) for the classification tree constructed by the CART algorithm was lower compared with Kucukonder et al. (2014), with accuracy classification ratios of 85.71, 91.58, 98.59, 91.06, and 99.73% for Naïve Bayes, KSTAR, ANN, RBF Network, and Ridor data-mining algorithms, respectively. The difference may be occurring as a result of differentness in handled factors, data mining algorithms, other management conditions, and genetic level. However, CART algorithm produces a decision tree diagram and the visual results are easier to interpret compared with the algorithms specified by Kucukonder et al. (2014).

It could be stated that the current classification tree data revealed more different information about fertility compared with similar studies. Nodes numbered 7, 10, and 11 produced the highest fertility ratios, which may be baseline information for further selection studies. Additionally, the classification tree result revealed that

Nodes numbered 0, 1, 2, 4, 5, 6, 7, 8, 9, 10, and 11 were characterized with fertilized eggs (fertile), but only two nodes numbered 3 and 12 were characterized with unfertilized eggs (infertile).

Since fertilized eggs positively affected hatching success, nodes producing high-fertilized ratio might be useful for quail producers in the practice.

Conclusions

The feather color factor should be taken into account for fertility ratio of Japanese quail in further (selection) studies together with characteristics such as weight, width, and height of the eggs, and the implementation of CART algorithm in next studies will produce beneficial reference in practice for detecting other characteristics affecting fertility in order to develop egg quality standards in it for the studied quail.

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