THE RELATIONSHIP BETWEEN PARENTAL DEFENSE INTENSITY AND NEST SITE CHARACTERISTICS IN EURASIAN MAGPIE (*PICA PICA* L.) - AN ASSESSMENT WITH THE CLASSIFICATION METHODS

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(Received 16th Jan 2017; accepted 20th Mar 2017)

Abstract. Nest defense behavior varies among species and depends on different factors. However little is known of the influence of urbanization and nest characteristics on the nest defense intensity as parental investment of the bird species. We observe the Eurasian magpie *Pica pica* nests to evaluate their nest defense behavior among those factors including urbanization degree of habitat, and nest characteristics such as nest volume, presence/absence of roof, offspring size and the number of offspring reduction for each breeding stages (incubation, early brooding and post brooding stage). To investigate the relationship between the nest defense behavior of Eurasian magpie and a set of those factors we used classification trees, binary logistic regression and random forest. According to our results nest defense strategies can be temporally changed primarily according to the nest volume with the auxiliary agents mostly a reduction of offspring number, which indicates parental capacities and offspring conditions could shape strongly their own nest defense strategies. Besides, we recommend classification trees, binary logistic regression and random forest modeling approaches to be considered individually or together for predictive mapping for ecosystem scientists.
Keywords: *nest defense, urbanization, offspring conditions, nest volume, binary logistic regression*

Introduction

Parental investment in offspring which have been shaped by natural selection is a tradeoff factor between reproduction output and parents budget of energy and time. Although parents can enhance the investment in offspring by increasing the intensity of nest defense over the breeding period (Redondo, 1989; Caro, 2005), nest defense behavior may vary among species and depending on offspring age (Curio et al., 1985; Montgomerie and Wheatherhead, 1988; Redondo, 1989), probability of parents' survival/renesting (Pavel and Bureš, 2008; Tilgar and Kikas, 2009), clutch/brood size (Olendorf and Robinson, 2000; Tilgar and Kikas, 2009; Svagelj et al., 2011), vulnerability level of offspring to predation (Redondo, 1989; Brunton, 1990), age linking residual reproductive value (Takata et al., 2016) and conditions of broods (Pavel and Bureš, 2001).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

Besides, the nest defense behavior which is the crucial thing of the parental investment is affected by the parents' quality (Hogstad, 2005). As it is commonly thought that successful parents as 'good' male and female (in terms of quality) should provide better nest conditions. So 'good' nest conditions should represent parental quality. In magpies, the roof structure of nests and nest volume are good indicators of parental quality as reflected parents' willingness to invest more in offspring (Soler et al., 1998; De Neve and Soler, 2002; De Neve et al., 2004; Quesada, 2007). Also, Møller (1990) indicated that nest volume probably covaries with the nest site quality and parents' nest defense intensity. In addition, high-quality habitat is accepted for minimizing the cost of reproduction effort of parents, and maximizing the survival chance of parents and fledging success (Hogstedt, 1981; Klopfer and Ganzhorn, 1985). Accordingly, it may refer to a direct relationship between those factors including parental quality, nest characteristics and nest site choice of parents. Thus, selection of high-quality habitat can be an indicator of parental investment.

Recent studies indicated that some generalist bird species called as urban adapters are able to maintain their reproduction output and reproductive success, and can benefit from the urbanized areas according to their tolerance to the urban stresses such as roads, build-up areas and disturbing conditions associated with human activities (Sawmiller, 2012; Yamaç and Kirazlı, 2012; Morelli et al., 2014). So ability to take advantage of urbanization can influence the ecological and life history traits of flexible generalist species (François et al., 2008; Balasubramaniam, 2014). For example magpies *Pica pica* as an urban adapter species have changed nest characteristics and added new food source, and thus they are successfully colonized in urban environments (Jerzak, 2001; François et al., 2008; Krystofkova et al., 2011; Kang et al., 2012). Because of less predator pressure and more accessible anthropogenic food resources, species spend their time and energy to rear successfull fledglings in the breeding period (Soler et al., 1995; Jerzak, 2001; François et al., 2008; Yamaç and Kirazlı, 2012). So it can be expected that magpies change their nest defense strategies in urban area which is the high-quality habitat for species.

If such nest characteristics (nest volume, roof) and nest site choice are good indicators of the parental quality and 'good' quality of nest and nest site provide reproductive success, the amount of investment in offspring and nest defense intensity of parents should vary according to nest site choice and nest characteristics. In this regard we predicted that in magpies species-specific nest defense behavior could be change during the breeding period according to the nest volume and presence/absence of roof (roofed or unroofed nest), and the gradient of urbanization (urban or rural habitat).

Previous studies in magpies revealed that nest defense behavior has a link with offspring age but not offspring size. Because of broods future reproductive probabilities increasing with offspring age correlates positively with lifetime reproductive success of parents (Redondo and Carranza, 1989). Nest defense increases with an increase of offspring number closing to the optimal size, however (Montgomerie and Weatherhead, 1988; Caro, 2005). Offspring size (number of offspring) certainly depends on the reproductive potential of the parents and also the potential differences of parents can generate different optimum size of offspring. Even so, it is argued that offspring size has minimal effects to the life histories of parents. Besides, parents can evaluate the amount of investment according to the number of offspring reduction rather than offspring size during the breeding period (De Steven, 1980; Tolonen and Korpimäki,

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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1995; Tilgar and Kikas, 2009). Thus, a considerable contribution of the number of offspring reduction might be found on the nest defense strategies of magpie parents rather than offspring size.

Due to ecological and behavioral flexibility, Eurasian magpie *Pica pica* is urban adapted species in the Palearctic Region (Jerzak, 2001). On the other hand knowledge about the effect of urbanization as a high-quality habitat on the nest defense intensity is insufficient. The main objective in the present study is to evaluate the role of nest site with the other crucial effects such as nest characteristics, clutch/brood size and the number of clutch/brood reduction on nest defense intensities of the urban-adapting magpies, and to classify the influence level of those predictor variables.

Material and methods

Study site

Our study was conducted at two nest sites, close to two different road types in Eskisehir (39°47′ N, 30°31′ E), northwest Turkey. The first road is a multi-lane highway and provides transportation between the cities of Eskişehir and Bursa. The traffic flow is quite heavy with cars and trucks all year round. The traffic density was estimated at 17302 vehicles/24 h in 2009 (General Directorate of Highways, 2010). The second nest site is located near a dirt road constructed from the natural material of the land surface (General Directorate of Highways, 2010). This road provides transportation to an agricultural area and to Karagözler village, and is generally used by farmers and villagers. The traffic density was approximately 100 vehicles /24 h in 2009 (General Directorate of Highways, 2010).

According to our comparative analysis of comparison, both nest sites had similar habitat conditions except for road type (Yamaç and Kirazlı, 2012), and included open agricultural fields. The greatest number of nest trees in both area was usually between the road and agricultural fields. The Black Locust (*Robinia pseudoacacia*) was the most widespread tree for each nest site. The Black Pine (*Pinus nigra*) was also found near the highway. The Black Pine, the Oriental Beech (*Fagus orentalis*), Almond (*Prunus dulcis*) and the White Willow (*Salix alba*) grew near the dirt road and all were used as nest trees by the species. A few buildings were located around the roads including a gas station, a restaurant and small dwellings near the highway, and farmhouses near the dirt road.

Study species

The Eurasian magpie (*Pica pica* L.) is a resident and territorial species (Holyoak, 1974; Baeyens, 1981a) that is widespread throughout Europe, Asia and Northern Africa (Del Hoyo et al., 2009; Svensson et al., 2009). The breeding range of magpies is associated with human settlements generally around farms and urban areas to profit anthropogenic food resources (Jerzak, 2001, Svensson et al., 2009). Holyoak (1974) reported that the Eurasian magpie’s evolutionary direction may firstly be from woodland or forest to scrub and open country, and it might secondly adapt to urban environments. Recent studies indicated that magpie populations in Palearctic urban areas dramatically increase in the 20th century (Jerzak, 2001). Magpies are monogamous and they can use same nest or built a new nest for each breeding attempt (Birkhead, 1991). In the Palearctic Region, 3-10 eggs (mostly 6-8 eggs) is laid from March to May (Birkhead, 1991). Roofed with the shape of sphere and unroofed with the

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shape of open cup nest are constructed by both sexes of magpies (Birkhead, 1991). The diet of the species includes grain, invertebrate such as insects and worms, small mammals, eggs and the nestlings of other birds (Baeyens, 1981a; Tatner, 1983; Buitron, 1988), and also anthropogenic food mostly from open trash bins and carcasses due to road collision and hunter kills (Mason and Macdonald, 1995; Jerzak, 2001; Wilmers et al., 2003). The potential predators of Eurasian magpies in the study areas are the Common Buzzard (*Buteo buteo*), the Long-legged Buzzard (*Buteo rufinus*), the Common Kestrel (*Falco tinnunculus*), the Rook (*Corvus frugilegus*), the Hooded Crow (*Corvus cornix*), the Red Fox (*Vulpes vulpes*), the Least Weasel (*Mustela nivalis*), and the Domestic Cat (*Felix catus*) (pers. observ.).

Field study and definitions

The study was conducted from late March to June. GPS was used to mark nest locations. To avoid road distance effects, only nest trees located at 0-10 m. from the road were selected. We obtained data on 76 nests with 39 from highways and 37 from dirt roads.

To score nest defense behavior, a human intruder was used as a potential predator which is accepted as proper for the studies of aggressive behavior (Caro, 2005). To assess urbanization and nest characteristics on nest defense behavior and evaluate the role of predictor variables, we investigated the changing defense intensity according to road types (reflecting environmental conditions in regard to urbanization), nest volume, presence/absence of roof, offspring size and the number of offspring reduction (both of them indicating parental quality and nest conditions) for three reproduction stages separately: (a) an incubation period which took 21 days from the laying of the first egg to hatching the first brood, (b) early brooding period which took a process from hatching to observing initiate fledging, and (c) post brooding period which included the period between initiate fledging the first brood and the fledging of the nestlings. The nest volume was calculated with the formula $4/3(\pi \times a \times b2)/1000$ (a: nest depth, b: half of the nest width), and nest depth was used instead of the largest Radius value to standardize for roofed and unroofed nest (see Soler et al., 1998). The 'offspring reduction level' (the number of offspring reduction) was calculated according to Tilgar and Kikas (2009), but the eggs and nestlings were not removed experimentally, so it was described as the sum of naturally disappearing offspring.

Each approach was started from the road and involved approaching the nest tree, climbing to the nest, checking the nest, climbing down from the nest and returning to the start point. The reproduction stages, clutch size, nestling and fledged number were recorded for each approach, and roof type was recorded when the nest first was discovered. To avoid familiarity effect with the human intruder, we generally considered the first experiments per reproduction stage. The experiment was performed at normal walking speed of one man. Nest defense intensity can change with weather conditions (Fisher et al., 2004), and therefore, we did not conduct observations on rainy or windy days.

Scoring the nest defense

Parents have to select efficient defense strategies to protect their nests and themselves (Buitron, 1983; Regelmann and Curio, 1983; Caro, 2005). Although nest defense strategies include different behaviors many researchers used a single act of behavior to

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quantify nest defense intensity (Gunness and Weatherhead, 2002). Some researchers tested different nest defense behavior, but they evaluated these effects as univariate (Olendorf and Robinson, 2000; Gunness and Weatherhead, 2002; Tryjanowski and Golawski, 2004). One alternative to these methods is to use a combination index of nest defense and to produce an overall defense score (Fisher and Wiebe, 2006; Redmond et al., 2009). In this context, we have suggested a new nest defense index and measured a total defense score for each approach over the nesting period.

The responses of magpies were grouped in the following variables which represent a total nest defense intensity to potential predators: (i) 'display initial position', is a position in which the bird first shows its distraction display to a human intruder; (ii) 'display duration', is a period in which a bird shows its display to a human intruder; (iii) 'parental response type' is defense behavior of the magpie which we ranked according to Baeyens (1981a), Röell and Bossema (1982), Buitron (1983) and personal observations; (iv) 'response distance', is the minimum distance between a human intruder and the bird; and (v) 'parental situation', was recorded according to how many individuals were found near the nest and showed a response to a human intruder. All variables were divided into 5 division and all divisions were ranked on a subjective scale from 0,2 (minimum defense to the potential predator) to 1 (maximum defense to the potential predator) (*Table 1*). The sum of the variables scores was used as an indication of the nest defense intensity of a pair of magpies for each approach.

Table 1. *Nest defense score of the magpie to a human intruder*

Description	Code	Score
Display initial position		
Approach from start point to the nest tree	b0	1,0
Climb to the nest	b1	0,8
Check the nest	b2	0,6
Climb down from the nest	b3	0,4
Return from nest tree to the start point	b4	0,2
Display duration		
All study duration (all above five duration)	t0	1,0
Four durations of five	t1	0,8
Three durations of five	t2	0,6
Two durations of five	t3	0,4
Only one duration of five	t4	0,2
Parental response type		
Attacking; pounce on a human intruder, pecking or kicking at human intruder, defending vigorously while sitting close to the nest	r0	1,0
Aggressive display; scolding with harsh notes continuously, dives above the nest	r1	0,8
Threat display; ground pecking, show wing- and tail-flirting, some chattering	r2	0,6
Inspection; take short approach and retreat by circling and flying, occasional short chatter calls	r3	0,4
There is no display; just observing from a distance	r4	0,2

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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Minimum response distance (meter)		
0-1	d0	1,0
2-25	d1	0,8
26-50	d2	0,6
51-75	d3	0,4
76-100	d4	0,2
Parental situation		
Both mates are near nest and respond with other individuals by gathering	f0	1,0
Both mates are near nest and show response	f1	0,8
Both mates stand near nest but one of them shows response	f2	0,6
One mate is near nest and shows response	f3	0,4
Both mates leave nest	f4	0,2

Redondo and Carranza (1989), used ‘calling rate’, ‘proximity to the human’ and ‘latency to approach and scold’ as dependent variables to assess nest defense by magpie. Results of their study showed that calling rate and proximity reflect the magpies nest defense intensity, but latency variables exhibit low relationship. Therefore, instead of latency variables we used ‘display initial position’ and ‘display period’. The duration was used in several studies in different ways to score nest defense (see Redondo and Carranza, 1989; Kis et al., 2000; Kleindorfer et al., 2005; Fisher and Wiebe, 2006). We suggest that the display duration is important for assessing effective nest defense. Thus, we divided the study duration into 5 periods and recorded in which periods birds displayed nest defense behavior and how many period birds defended nests for each approach. Holyoak (1974) and Baeyens (1981a) show that the breeding and non-breeding magpies often mob human intruders, cats or other potential predators near nests as a group. Møller (1983), reports that the flocking may be an adaptation to defense against interspecific competitors and mates usually display cooperative defense to discourage predators (Röell and Bossema, 1982; Buitron, 1983 and 1988). Therefore, we also used the ‘parental situation’ to score nest defense intensity.

Statistical analysis

We implemented statistical models using classification methods rather than conventional methods.

Binary logistic regression

Logistic Regression Analysis (LRA) is one of the mostly used statistical tool to determine the relationship among the binary response variable and predictor variables. It is also used to categorize the response variable as a probabilistic classification tool. Most regression models predict the average value of response variable taking into account predictor variables. Unlike them, LRA predicts the probability of possible outcome of response variable.

The three most used logistic regression models popular in research are binary, ordinal and multinomial logistic regression models. We examine a binary logistic regression model since this study is only constructed on a binary response variable.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

When the response variable has two different outcomes binary logistic regression model is preferred. For example, the response variable has two outcomes such as damaged-healthy product, occurred-not occurred case, bad-good weather, and etc.

Classification trees

One of the nonparametric methods of sorting data in the statistical community is the Classification and Regression Trees (CART) algorithm (Breiman, 1984). CART produces a classification of data into groups and obtain a decision tree. It is structured using a binary recursive partitioning algorithm. Hence the tree is obtained by splitting based on several predictor variables. The root is split into two nodes and each node is also split into two other nodes by asking that have 'yes' or 'no' answer recursively. The process is repeated until the tree is impossible to grow. The aim of CART is to predict or classify the cases according to the response variable.

Random forest

Random forest is also one such method of data mining. It is similar to classification trees. Basically, multiple trees are constructed and each tree is grown with a randomized subset of predictor variables. A large number of trees (default value is 500) are grown, hence these are the reasons of why it is called together 'random' and 'forest'. The number of the explanatory variables at each node randomly selected to find the best split. As a result, the trees are grown to maximum size (e.g. 2000). It then combines the predictions from all trees. The observations which are not in the bootstrap sample but in the original data set are called out-of-bag observations. For each of the trees, there is a misclassification rate for the out-of-bag observations. These observations are used to calculate the unbiased error rates and accuracies. The accuracy measures were the overall percentage of correctly classified (CC), the percentage of true negative rate (Specificity), and the percentage of true positive rate (Sensitivity). The ranking of the predictor variables was assessed by variable importance plots.

Missing data

It is quite common to have some observations with missing values for two of the predictor variables. The usual approach to impute the missing values in some ways (Hastie, 2008). For most of the learning methods, the imputation is needed. The simplest way of imputation is to use the mean or the median of the nonmissing values for corresponding variable. In this study, we used a sampling algorithm with replacement for imputation of the missing values.

After the imputation, the missing values are treated as they were actual values. The names of the predictor variables with missing values in the data set are the nest volume and the number of brood reduction for early brooding period. The name of the predictor variables with missing values in the data set is the nest volume for both post brooding period and incubation period.

Results

First of all, this study provides statistical models for comparison in terms of prediction accuracy. It differs fundamentally from conventional methods that aim to fit single models. It illustrates the effect of each predictor variable and interprets the

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prediction accuracies to enable the wider use of statistical modeling by ecologists. It serves an opportunity to identify the relationship between a response and explanatory variables for further predictions.

Within the area of the Eurasian magpie nest sites, a total of 135 data sets were randomly selected, and the same information was collected for three period. The predictor variables for those analyses were the nest volume, presence/absence of roof, road type, offspring size (clutch size for incubation period, brood size for early brooding period, fledgling size for post brooding period), the number of offspring reduction (the number of clutch reduction for incubation period, the number of brood reduction for early brooding period, the number of fledgling reduction for post brooding period). The response variable is a categorical variable that is defined as the nest defense behavior of Eurasian magpie is sufficient (coded 1≥Mean+Standart Deviation of Nest defense score for each reproduction period) or insufficient (coded 0< Mean+Standart Deviation of nest defense score for each reproduction period).

The first data set (n=59, randomly sampled observations) collected from roads on the ways to Bursa (coded 0) and Karabayır (coded 1) was used for incubation period. The second data set (n=39) collected from the same region was used for early brooding period. The last data set consisting of randomly sampled 37 observations collected from the same region was used for post brooding period. The presence/absence of roof of the nests was scored as roofed (coded as 1) or unroofed (coded as 0).

We applied random forest, logistic regression and classification trees to classify the behavior of Eurasian magpie based on the sites of likely occurrence of their nests. In *Table 2*, we compare three methods with each other in terms of accuracies. The accuracy measures used were the overall percentage correctly classified (CC), specificity (percentage of true negative rate) and sensitivities (percentage of true positive rate) between predicted sufficients and insufficients with actual sufficients and insufficients.

According to the results given in *Table 2*, the highest CC (percentage of correctly classified) was obtained as 72% by LR estimation whereas the lowest CC was obtained as 56% by Random Forest for post brooding period. The highest CC was obtained as 71% by classification trees whereas the lowest is obtained as 47% by Random Forest for incubation period. The same results were hold for the early brooding period as well.

The highest estimated specificity (percentage of true negative rate) is obtained as 71% by classification trees whereas the lowest specificity was obtained as 42% by Random Forest for post brooding period. The highest the estimated specificity (percentage of true negative rate) was obtained as 77% by LR estimation whereas the lowest specificity was obtained as 62% by Random Forest for incubation period. The highest the estimated specificity (percentage of true negative rate) was obtained as 58% for early brooding period by LR estimation whereas the lowest specificity was obtained as 41% by Random Forest (*Table 2*).

The highest sensitivity (percentage of true positive rate) was obtained as 90% by classification trees whereas the lowest sensitivity was obtained as 68% by Random Forest for early brooding period. The highest sensitivity (percentage of true positive rate) was obtained as 66% for incubation period by classification trees whereas the lowest sensitivity was obtained as 25% by Random Forest. The highest sensitivity (percentage of true positive rate) is obtained as 78% for post brooding period by LR estimation whereas the lowest sensitivity was obtained as 65% by random forest.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

Overall, classification trees and logistic regression were the highest accuracy values whereas RF had the lowest values among the periods.

Table 2. *Comparing three methods with each other in terms of accuracies*

Accuracy	Classification Trees			Logistic Regression			Random Forest		
	Inc. per.	Early b.p.	Post b.p.	Inc.per.	Early b.p.	Post b.p.	Inc. per.	Early b.p.	Post b.p.
CC (%)	0.71	0.71	0.59	0.61	0.66	0.72	0.47	0.56	0.56
Specificity (%)	0.74	0.47	0.71	0.77	0.58	0.56	0.62	0.41	0.42
Sensitivity (%)	0.66	0.90	0.69	0.35	0.72	0.78	0.25	0.68	0.65

Inc. per. : incubation period; Early b.p. : early brooding period; Post b.p. : post brooding period.

The most widely used variables are generated by random forest algorithm. By classifying the data, the importance of every variable is listed in a graphical way. The ranking of the predictors by their importance is given by dots on the figure. *Figure 1* shows the variable importance measured for the first data set (incubation period). In the figure, large breaks between variables are what it is looked for. Such a similar case can be found between the nest volume and the rest of the variables. Therefore that plot is an important tool to reduce the number of important variables. The mean decrease Gini that represents a measure of how each variable contributes to the homogeneity of the nodes and leaves in the resulting random forest. In decreasing order of importance the other predictors included in the RF model for incubation period were: the number of clutch reduction, clutch size (the number of clutch), type of road, presence/absence of roof (roof type).

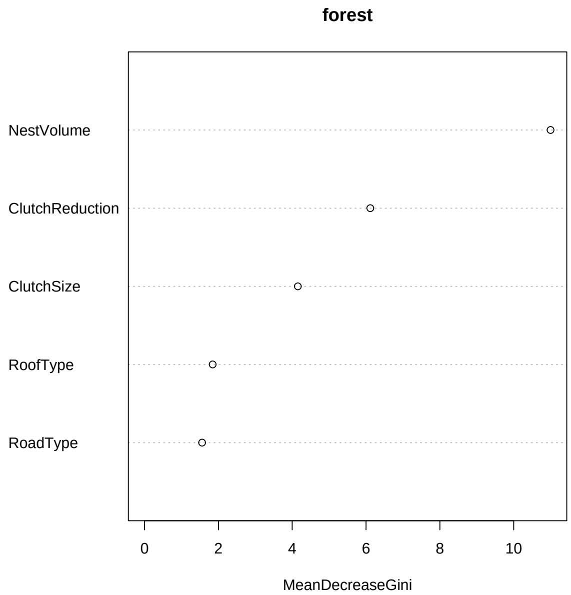

Figure 1. *Variables Importance of incubation period*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

Figure 2 shows the variable importance for the 2nd data set (early brooding period). The variable importance is similar to the 1st data set but somewhat higher than those in the early brooding period. In decreasing order of importance the other predictors included in this model were: the number of brood reduction, brood size (the number of brood), presence/absence of roof (roof type), type of road.

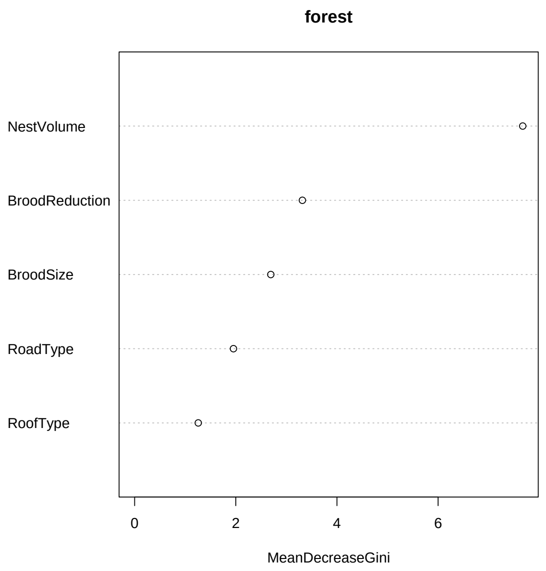

Figure 2. *Variables Importance of early brooding period*

Figure 3 represents the importance of variables for the 3rd data set (post brooding period). It appears the nest volume and the number of fledgling reduction to be the most two important variables for the post brooding period. In decreasing order of importance the other predictors included in this model were: fledgling size (the number of fledgling), type of road, presence/absence of roof (roof type).

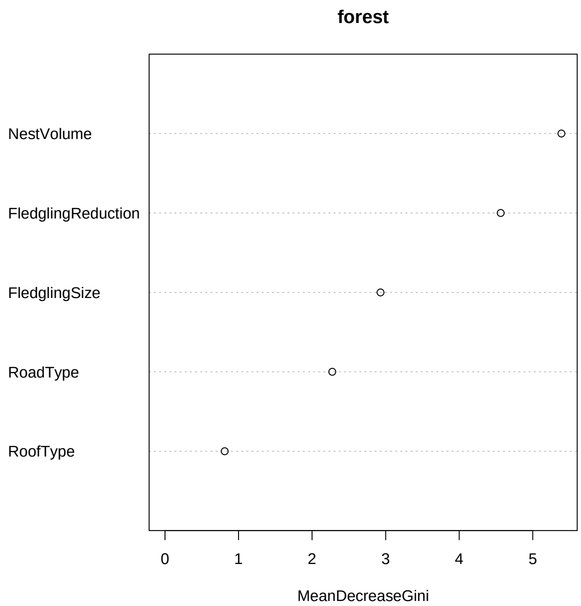

Figure 3. *Variables Importance of post brooding period*

APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 15(3): 1293-1308.
http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

Discussion

The reproduction process provides a challenge between inheritance of genes of own to the future generations and protection of own future reproductive value during an attack on their reproductive investment. In regard to natural selection, parents should evaluate their environmental and own conditions in a faultless way or in the context of minimal fallacy in order to be successful. Previous studies clearly demonstrated that parents' investment strategy has been effected by environmental conditions in terms of food abundance and predation risk, and it changes during the reproduction progress (Fontaine and Martin, 2006; Rastogi et al., 2006; Dassow et al., 2011). In other words, parents could spend a more successful breeding process while the environmental conditions are in favor of them. For example, in black-billed magpies food-supplemented parents gaining more time and energy for guarding nestlings had high reproductive success (Högstedt, 1981; Dhindsa and Boag, 1990). Similarly, Eurasian magpies breeding in urban environments can adjust the advantage of environmental conditions, the lack of intensely predation pressure, presence of favorable circumstance temperature and food abundance with anthropogenic nutrients to their reproductive output (Jerzak, 2001; Yamaç and Kirazlı, 2012). Therefore, one can expect that magpie parents would adjust the environmental conditions relating with urbanization largely to the nest defense behavior during the breeding period. However, according to the results of this study, the traits of parental and offspring conditions has been used primarily for the nest defense behavior rather than environmental conditions during the each breeding period of the magpies. As it is known that nest volume acts as an indicator of parental conditions and quality, and thus construction process of nest helps magpie females to assess the quality and willingness of males to invest in reproduction (Soler et al., 1998; De Neve and Soler, 2002; De Neve et al., 2004). This study supports and expands those concept mentioned above. Accordingly, nest volume is the primary factor indicating the willingness of parents to invest in nest defense as it might be expected. In magpies, the strategy of parental investment shaping by many factors like other bird species such as age, sex, residual reproductive value of parents, reproductive value of offspring, food availability, predator pressure and habitat connectivity (Baeyens, 1981a; Högstedt, 1981; Eden, 1985; Redondo and Carranza, 1989; Dhindsa and Boag, 1990; Kang et al., 2012), seem to be initially influenced by own capacities and conditions. Nevertheless, parents pick up information particularly about offspring condition (the number of clutch/brood/fledgling reduction), and strongly adjust investment according to the reproductive value linking survival chance of offspring over the breeding period (Redondo and Carranza, 1989).

Our results suggested that if offspring condition give positive signals to parents like minimal reduction of offspring number, the nest defense intensity should increase exponentially. Although the offspring size can affect the nest defense strategies (Olendorf and Robinson, 2000; Rytkönen, 2002; Svagelj et al., 2011), in agreement with the study of Tilgar and Kikas (2009) magpie parents can shape their investment amount according to the offspring reduction as auxiliary agents more than offspring size. The future reproductive possibilities may affect nest defense strategies and lead to an age-dependent investment for current clutch or brood (Hatch, 1997; Pearson et al., 2005). Thus, we may expect that older magpie parents invest much on a current large offspring size as opposed to younger parents. However breeding individuals of different ages have similar perception about the costs and benefits of their investment (Fisher and Wiebe, 2006), and also to increase lifetime reproductive success, different clutch or

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DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

brood size which perceived both as optimal for each parents, represent equal value in regard to defense (Caro, 2005; Gross, 2005). Furthermore, nest defense intensity by magpie increase with the reproductive value of offspring, and the value enhancement link with survival probability of offspring (Redondo and Carranza, 1989). At each life history transition, such as from incubation to brooding stage, the survival probability of offspring just after hatching was lower than for those at the end of the incubation period (Low and Pärt, 2009). If a chick survived this period called the 'bottleneck phase', then parents promote their investment to broods according to the own capacities (Redondo and Carranza, 1989). The brood reduction at the transition provides optimizing the number of young by parents according to their ability to raise (Husby, 1986). In this context the offspring reduction rate could indicate the quality of environmental conditions and survival chance of clutch or broods for parents. Thus magpie parents could adjust those informations from nest to the willingness of nest defense and accordingly could shape investment strategies in a temporal context.

We can also argue that the urbanization degree of habitat such as dirty road representing rural habitat and highway representing urban habitat, and the roof structure could be the indirect agents as information sources on environmental pressure. However, they have lesser effect than other variables mentioned above (nest volume, offspring reduction level) for temporally shaping nest defense strategies by magpie parents according to our results. Additional food resources like waste discarded or road-kills, less predator activity and also more appropriate winter temperature in urban areas play a considerable role for successful colonization in urban areas (Eden, 1985; Jerzak, 2001; Bautista et al., 2004; François et al., 2008; Krystofkova et al., 2011). The energy demands of both of adults and broods increased day by day over the breeding period of magpies (Buitron, 1988). Limited food supply is one of the most important reasons of nest failure and high bird mortality rate (Högstedt, 1981), and thus there is a significant relation between food abundance and availability, and survival success of nestlings and breeding success (Yom-Tov, 1974; Högstedt, 1981; Dhindsa and Boag, 1990; Rastogi et al., 2006; Harrison et al., 2010). Food availability can also lead to a change aggressive behavior of parents like food supplemented parents increased nest attentiveness in response to guard their investments, and exhibited riskier defense behavior (Högstedt, 1981; Dhindsa and Boag, 1990; Rytkönen, 2002; Rastogi et al., 2006). Additionally, according to a predation risk assessment (see Fontaine and Martin, 2006; Dassow et al., 2011), if the threat of predation varies along the urbanization stages (Eden, 1985; Rodewald et al., 2011) then parents' nest defense strategies can be modified with respect to this. Therefore, magpie parents could benefit from the above advantage of urban areas, and because of their flexibility (Jerzak, 2001), they could use the environmental conditions like the status of food availability and predation pressure as indirect agents to temporally shaping nest defense strategy, but not primarily according to our results as we mentioned above.

Nest characteristics such as roof affecting the probability of nest predation may become particularly important for parental investment and be modified by avian nest defense strategies. Roofed nest construction requires more time and energy than unroofed nests and it helps to conceal and protect the nest contents (Baeyens, 1981b; Röell and Bossema, 1982). Besides, the roof structure of magpies nests can show the potential parental ability to reduce the risk of predation (Quesada, 2007), but not primary indicator, according to our classification analyses it has minimal influence to indicating the willingness of nest defense comparing the other variables as we tested.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1503_12931308

Moreover, in our study, we can hypothesize that the roof presence/absence contributed more in regard to assessing investment amount as aggressive behavior by magpie parents in the incubation period rather than brooding stages due to maybe higher predation risks on eggs.

Consequently, our results prove that parental conditions and capacities which can be assessed by nest volume, could control the investment amount of parents to the offspring as a primer indicator meaning that parents could evaluate own capacities and have greater control on nest defense behavior. Nest defense strategies can be also temporally changed with the other factors mostly a reduction of offspring number, following offspring size, urbanization, roof structure as auxiliary agents indicating environmental and nest conditions.

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