HOCHSCHULE WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Fakultät Wald und Forstwirtschaft

Modellstudie zur Nutzung der Schlüsselstruktur Schwarzspechthöhle

Wie beeinflussen forstliche Parameter Konkurrenz und Prädation?

Abschlussbericht über ein Forschungs- und Entwicklungsprojekt

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Projektkennblatt

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Stichworte	

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Zielsetzung und Anlaß des Vorhabens

Die Schwarzspechthöhlen stellt eine Schlüsselstruktur für eine Reihe von streng geschützten Arten der verschiedensten Taxa dar. Die Auswahl des Nistplatzes bzw. des Höhlenbaums entscheidet maßgeblich über den Erfolg oder Misserfolg der Fortpflanzung. Neben wetterbedingten Ausfällen ist die Prädation ein ganz zentraler

Faktor für den Brutverlust und damit für die Höhlenauswahl. Entsprechend stark, so die Erwartung, muss die Konkurrenz um die besten, also sichersten Höhlen sein. Zahlreiche Arbeiten belegen, dass verschiedene Vogelarten in der Lage sind die Prädationsgefahr einzuschätzen und darauf angemessen zu reagieren.

Auf der anderen Seite stellt sich die Frage, welches die wichtigsten Prädatoren sind und welche Strategie diese verfolgen. Es lagen bis heute hierzu keine systematischen Untersuchungen (24 Stundenerfassung) über Konkurrenz und Prädation in Spechthöhlen an einer größeren Zahl von Höhlen vor, da hierzu bis vor kurzem die technischen Möglichkeiten nicht existierten.

Welche Höhlenbäume aber tatsächlich zur Verfügung stehen und wie diese in das Raummuster eingebettet sind (Alter, Baumartenzusammensetzung, Bestandgröße, Verjüngungsansätze, Schaftlänge) ist in bewirtschafteten Wäldern ein Produkt der Forstwirtschaft. Gerade bei der Buche als wichtigstem Höhlenbaum des Schwarzspechtes sehen neuere Erziehungskonzepte die Produktion von Starkholz in deutlich kürzeren Zeiträumen vor, mit unklaren Auswirkungen auf die Höhlenbrüter. Die Zielsetzung dieses Vorhabens war es die Lebensgemeinschaft der Schwarzspechthöhle und ihre Interaktionen in überwiegend bewirtschafteten Wäldern zu analysieren, darin Muster zu erkennen, potenzielle Risiken zu ermitteln, um daraus Vorschläge für den Biodiversitätsschutz in Buchen-(misch)wäldern abzuleiten.

Dabei stellt sich die Frage welche Arten die erfolgreichsten bei der Besetzung der Höhlen sind und welche Strategien die weniger erfolgreichen Arten verfolgen. Gibt es Unterschiede in der Präferenz für Höhlen z.B. was die Höhe der Verjüngung unter dem Höhlenbaum oder das Alter der Höhle bzw. die Dimension des Höhlenbaumes betrifft.

Auch wird ein Zusammenhang mit der forstlichen Bewirtschaftung untersucht. Haben Buchen in Fichtenbeständen eine höhere Prädationsrate und sind sie umkämpfter oder weniger beliebt? Die Frage welche Höhlenbewohner besondere Habitatparameter bevorzugten ist der erste Schritt diese auch forstlich zu erhalten. Wird die Höhle nicht mehr angenommen, wenn die Naturverjünung zu hoch ist und in der Umgebung keine geeigneten anderen Flächen vorhanden sind? Lässt sich mit Licht und Schatten die Zeitspanne verlängern, bis die zeitliche Lücke geschlossen ist.

Am Ende des Projekts sollen die Erkenntnisse unmittelbar in die Arbeit der beteiligten Forstbetriebe einfließen und Teil ihrer Naturschutzstrategie werden.

Darstellung der Arbeitsschritte und der angewandten Methoden

In 7 verschiedenen bayerischen Waldgebieten mit unterschiedlichen Buchenanteilen (Steigerwald Nord und Süd, Hienheimer Forst, Schongau, Freisinger Forst, Gelnhauser Wald, Bayerischer Wald) wurden Wildtierkameras (Fotofallen Typ Cudde back attack IR) mit Foto und Videofunktion ca. 3 m oberhalb von Schwarzspechthöhlen durch Baumsteiger nicht invasiv auf einem Trägerschlitten angebracht, der über einen Seilzug vom Boden aus gewartet werden konnte.. Die Kameras lieferten im Durchschnitt 104 Tage rund um die Uhr Informationen über das Leben an der jeweiligen Baumhöhle.

Nach Fertigung der Trägerschlitten, der Schulung der Hilfskräfte und der Suche von geeigneten Schwarzspechthöhlen wurden vor Beginn der Brutzeit insgesamt 72 Buchen mit Kameras bestückt. Die entstandenen Bilder wurden über Lightroom ausgewertet und über verschiedene statische Pakete und Modelle (Random Forest, R, SPSS) bearbeitet.

Ergebnisse und Diskussion

An 72 Schwarzspechthöhlen wurden über 104 Beobachtungstage mit annähernd 100.000 Bildern insgesamt 24 Wirbeltiere nachgewiesen. Dominiert wird die Höhlengemeinschaft von Hohltauben mit über 50 % gefolgt vom Schwarzspecht mit 11%. Nur 4% der Höhlen waren verwaist. In anderen Bäumen nutzten sogar mehrere Arten die Struktur gleichzeitig (Hohltaube und Raufußkauz im selben Baum/ Hohltaube als Brutvogel und Schwarzspecht als Schlafnutzung sowie Fledermäuse als Tagesquartier in der gleichen Höhle). Im Durchschnitt konkurrierten 3 Arten um eine Höhle. Dies verdeutlicht, dass Großhöhlen einen Minimumfaktor in unseren Wäldern darstellen, die zentrale Bedeutung für die Biodiversität haben. Bisher nicht bekannt war der Umfang der Beutegreifergemeinschaft an diesen Höhlen. Die Zahl an Tagprädatoren ist fast gleich groß wie die der Nachtprädatoren. Neben Mäusebussard und Habicht, die erstmals nachgewiesen wurden, trat auch der Buntspecht recht häufig auf. Der Schwarzspecht scheint mit seinem Höhlenbau und seiner Nistplatzwahl besonders die Feindvermeidung zu optimieren und verteidigt obendrein seine Höhle aktiv. Das erklärt u.a. die deutlich geringeren Verluste im Vergleich zur Hohltaube. Das forstliche Management hat direkt Einfluss auf die Entwicklung der potenziellen Höhlenbäume und damit auf die Umweltkapazität der Folgenutzer.

Öffentlichkeitsarbeit und Präsentation

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Fazit

Schwarzspechthöhlen sind Schlüsselstrukturen, die komplexere Bedeutung im Ökosystem Buchenwald haben, als bisher angenommen. Während das Spektrum der Höhlenbewohner in der Literatur vollständig erfasst ist, ergaben sich bei der Prädatorengemeinschaft Überraschungen. Das Vorkommen und die Häufigkeit vom Mäusebussard als Prädator an Höhlen ist neu. Auch der Habicht ist nicht als Höhlenprädator erwähnt. Ein wesentlicher Faktor für die Höhlenwahl von Schwarzspecht und Hohltaube ist aber offenbar gerade die Feindvermeidungsstrategie, besonders vor dem Baummarder, der einen Totalverlust der Brut bedeutet. Es zeigte sich, dass der Schwarzspecht zur Feindvermeidung gezielt Bäume wählt, die eine gewisse Deckung durch die Naturverjüngung aufweisen und die von ihm angelegten Höhlen möglichst weit oben am Stamm liegen. Bevorzugt werden eindeutig vorherrschende Buchen mit astfreien Schaftlängen >12m. Diese Strukturen werden dann über lange Zeiträume (Jahrzehnte) immer wieder genutzt.

Damit die Naturverjüngung nicht die Höhle zu rasch entwertet, sollten Höhlenkomplexe im Buchenaltholz besonders lange Dunkel gehalten werden. Neue forstliche Konzepte zu Kurzumtrieben in der Buche, bei der wenige Stämme (ca. 60/ ha) in unter 100 Jahren zu Dimension und Erntereife gebracht werden sollen, laufen diesen Ansprüchen entgegen. Die Stammhöhe bleibt niedrig (erhöhtes Prädationsrisiko) und durch die lichte Waldstruktur kommt die Naturverjüngung rasch und flächig auf und vermindert die potenzielle Nutzungsdauer deutlich. Insgesamt deutet dies auf eine Verringerung der Brutkapazität/ Umweltkapazität beim Schwarzspecht, vor allem bei seinen Folgenutzern hin. Um dies zu vermeiden sollten höhlenreiche Reproduktionszentren (Höhlenzentren) vom Schwarzspecht und seinen Folgearten solange relativ dicht gehalten werden, bis andere Buchenbestände in ein relevantes Alter und Dimension gewachsen sind. Dabei zeigt sich, dass zwischen Höhlenzentren zweier Schwarzspechtpaare mindestens ein Abstand von 400 m liegt.

Research Study of the key structure Black Woodpecker cavity

What is the impact of forestry due to completion and predation?

Projektkennblatt 3

Keywords: Stock Dove, partial nest losses, raptors, adaptive response, camera trap survey, new predators, beech forest 9

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Keywords: Stock Dove, partial nest losses, raptors, adaptive response, camera trap survey, new predators, beech forest

Abstract

Selecting a cavity tree a Woodpecker has to find a compromise between energy expenses of excavation, nesting tree availability and predation risk. An optimal strategy may vary with a change in tree species and predation risk. While primary excavators have a larger choice, secondary cavity nesters have to have other strategies and underlie higher predation rates. A camera trap survey of Black Woodpecker cavities was conducted with 72 infrared triggered cameras for an average of 104 days in seven areas. 24 vertebrate species were recorded during the study. This structure seems to be limited because of a strong interspecific competition.

The results show new aspects of the community of cavity nesters and their predators. The cameras offer behaviors of competition and predation at the cavities. In the food web the cavities are a source for predators with a strong impact to their prey. While the Pine Marten (*Martes martes*) is well known, the Goshawk (*Accipiter gentilis*) and the Common Buzzard (*Buteo buteo*) are newly found predators at this structure. All together at 72% of all cavities a predator appeared. Because Raptors show only partial predation on the nestlings the main threat for the brood is the pine marten and for the adult bird the Goshawk. The black woodpecker appears to be able to detect predation risk and to respond adaptively by selecting the most appropriate available cavity site. Cavity height over 12 m and rejuvenation height 30% of the cavity height were the strongest predictors in our model (Random Forest Model), while cavity age and cavity clusters were not important. The predator species appear to prefer special structural patterns in the forest or at the cavity tree. The pine martin did not climb higher than 15m and the Goshawk preferred cavities with a distance to the tree crown.

Introduction

Nest predation is a major reason of nest loss and accounts up to 80% of all nest failure (Martin 1993, Ryan et al. 2006). Species nesting in cavities show reduced nest predation rates and increased nest survival (Fontaine et al. 2007). In Europe only seven woodpecker species and two tits (Willow and Crested) are known as excavators (Cockle et al. 2011). Most cavity users are secondary cavity nesters and not able to excavate. Their population is limited by the number of available cavities (Newton 1998). While in the primeval forests of Eastern Europe 10 to 69% of cavities used by secondary nesters were made by woodpeckers (Cockle et al. 2011). Woodpecker species are even more important in managed forests because of the lack of decay formed holes (Cockle et al. 2011). Large cavities of the black woodpecker have a special role in the Palearctic forest ecosystem. These are used by over 60 animal species (Marques 2011). This may indicate inter- and intraspecific competition for nesting sites.

The large cavity entrance of a Black Woodpecker cavity enables predators to enter the nest. Which predator imposes the highest potential threat to these cavity nesters and are there behavioral patterns or strategies to minimize predation risk? Does forest management implies an impact on this relationship?

The pine marten is often mentioned as the main predator of these cavities (f.e. Möckel 1988, Sonerud 1985, Sonerud 1989, Marchesi 1989, Gorman 2011, Korpimäki 1987). This mammalian predator uses cavities to give birth and to rear their young (Marchesi 1989, Stier 2012). But traces of feathers, eggshells or scratches on the trees indicates that this species also cause complete nest loss.

Nothing is known about raptors and their role as cavity nest predators. The latter species are too large to enter cavities. They could cause partial or incomplete predation. Video surveillance of open nests has shown partial failure (Miller& Leonard 2010). However, this has not generally being detected by former studies.

Several studies have dealt with predation of black woodpecker cavities. However, problems have been identified such as disturbing the brood while climbing the tree or investigating the nests after long intervals of 3 to 7 days (Rolstad et al. 2000). With “new” techniques new answers are possible. Very view studies of cavity nesters positioning camera traps have been done before. This is the first study positioning camera traps to investigate cavity nesters in beech forest ecosystems.

Methods

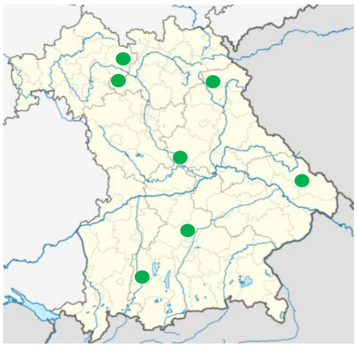


Figure 1: Location of the seven study areas in Bavaria.

Study sites

The study was carried out in the continental zone of central Europe in seven woodland areas of southern Germany in 2012 and 2013. Elevation of the woodland areas ranged from 400-800 m a.s.l. (Ebrach, Bad Rodach, Gelnhauser Forst, Kelheim, Hienheimer Forst, 48°54’ N, 11°48’ E (in the centre), Bavarian Forest Nationalpark, Freising, Freisinger Forst, Landsberg am Lech).

Beech (*Fagus sylvaticus*) and occasionally Norway spruce (*Picea abies*) dominated the forests. The proportion of beech ranged from 20% in the Bavarian Forest to 98% in the region of Ebrach, Steigerwald. The share of beech ranged from small beech patches in Norway spruce forests Landsberg/ Lech to large beech dominated forests in Ebrach.

Study trees and Camera traps

We focused our study on old beech stands (100 years and older)(Lange 1993), since the black woodpecker prefers large beech trees to excavate cavities (tree diameter at the cavity entrance > 38 cm, Glutz von Blotzheim & Bauer 1980). The beech is the most important cavity tree species in central Europe (Meyer & Meyer 2001, Gorman 2011). Previous surveys of black woodpecker cavities have being carried out in the selected study areas (Ebrach by Mergner, Freising University Forest, Kelheim by Sikora, Landsberg by Zeimentz, Bavarian National Park Research unit). We placed the cameras over mapped cavities. Cavities included in this study had to meet specific criteria. The cavity had to be excavated by a black woodpecker and had to be suitable for large cavity nesters (vertebrates). A tree climber checked the suitability of cavities as nesting sites. The climber strapped a camera carrier between 2 m and 4 m above the entrance of selected cavity. The camera unit was drawn up with ropes and installed. The function and position of the camera was tested from the bottom with the help of a SD-Card viewer. Cavity trees in 7 Bavarian forests were selected to place a camera trap with video surveillance. All together we placed 72 cameras. The cavities were monitored for three and a half month throughout middle March until the end of June.

In the vicinity of the selected cavity trees (15 m radius) we measured the height of rejuvenation according to the cavity entrance (in m), the number of black woodpecker cavities on a ha plot (cavity clusters) and the distance to the next spruce patch.

For each cavity tree, we recorded the following measures: tree species, social classes proposed by Kraft 1884 (cited in Burschel and Huss (1987): 1 = tree is predominant, 2 = dominant, 3 = subdominant, 4 = suppressed, 5 = understory) in the stand, diameter at breast height (dbh), diameter at the cavity, exposition of the cavity (main compass directions), age of cavity (fresh or old) and the distance to the tree crown (nearest distance of the cavity to the next branch).

We used 62 Cudde back attack IR, and 10 HC600 Reconyx camera traps. The Cudde back attack IR camera has a fast trigger speed of 0.25 seconds and a recovery time of 15 seconds. It has a sensor distance of 15 m and a solution of 3 Megapixel. The cameras were driven with 4 batteries LR20 Mono. The images were stored on a 16 MB SD-card. The produced images were in color by daylight and black and white at night time. We used the additional video option of 30 second film in some cavities to gain further information. After an initial trial we identified that a passive infrared-triggered camera trap with an infrared flash is more ideal than a white flash. A strong white flash was thought to have negative impacts on nocturnal predators like pine martens and owls and individual recognition was not necessary. The camera was motion triggered. When a permanent subject was detected in a cavity entrance a picture was taken every minute to avoid too many pictures of the same event. 8 cameras were replaced during the next maintenance check. To prevent theft bear boxes were used in the surrounding of human settlements.

All images were classified with the program light room. If an image showed no object it was defined as unidentified. This happened occasionally mainly caused by stock doves entering and leaving the cavity quicker than the camera could release.

Predators found in a nest with brood was defined and recorded as a predation event. Different predators at the same nest were counted as distinct predation events. Squirrels and Tawny owls were not defined as predators, except if a brood was already in the cavity. Except for bats identification to species level was possible.

To avoid adaptation of the predators which may affect predation rates and the results, cameras were placed only for one year in a specific area and restricted to a maximum of 10 cameras per area.

Statistical analyses

The multivariate statistics package fandom forest was applied. It is a fully nonparametric statistical method to characterize, exploit and identify ecologically important variables (Cutler et al. 2007). With rising computational power several algorithm-based developments of regression models appeared (Berk 2006, Hastie 2009, Strobl 2009). Random forests became especially popular during the last recent years (Hastie et al. 2009)

Rand

om Forests bear on tree-based methods and can be applied for regression as well as classification. The random forest algorithm collects many de-correlated trees and averages them (Hastie et al. 2009). When using random forests for classification, a class vote from each tree is obtained and classification is done by majority the votes (Hastie et al. 2009). When used for regression, the predictions from each tree at a target point are averaged (Hastie et al. 2009).

Advantages are the high predictive accuracy (Cutler 2007) and the ability to derive descriptive variable important measures which reflect the impact of each predictor variable in both main effects and interactions (Strobl et al. 2009). Analyses were done in R and in SPSS Statistics 18.

Results

Cavity trees

The selected black woodpecker cavity trees were found to be potential nesting cavities for black woodpeckers or other birds and mammals from the community. The social class of the cavity trees in the stands were predominant (mean class=1.2, SD= +0.4). The mean diameter in breast height (DBH) of cavity trees was 63.6 cm (SD=+10). The average cavity height was 12.3 m (SD=±3.3). 25 cavity trees had two entrances or cavities (35%). The average distance between cavity height and the start of the tree crown was 4.6 m (SD= ± 3.3). The rejuvenation height around the cavity trees was in average 3.1 m (SD=±2.8). Two new cavities were identified.

On average the cameras were operating 104 days, 24 h a day. All together we had 7280 camera days and a total of 97000 visitation events were recorded. Twenty four (identified) vertebrate and two insect species were detected. Nesting, visiting or depredating on vertebrate level comprised of mammals (≥5 species) and birds (18 species). Of the birds five species were woodpeckers, three species were tits (great-, blue-, willow tit), two species were raptors (Common Buzzard, Goshawk) and three species owls (Tawny-, Boreal-, Ural-). Four species (Jay, Common Buzzard, Goshawk, Ural owl) were found to be non-cavity nesters. Only 4% of the cavities were visited, with a mean number of visitations of 2,9 species (SD =±1.6) per cavity.

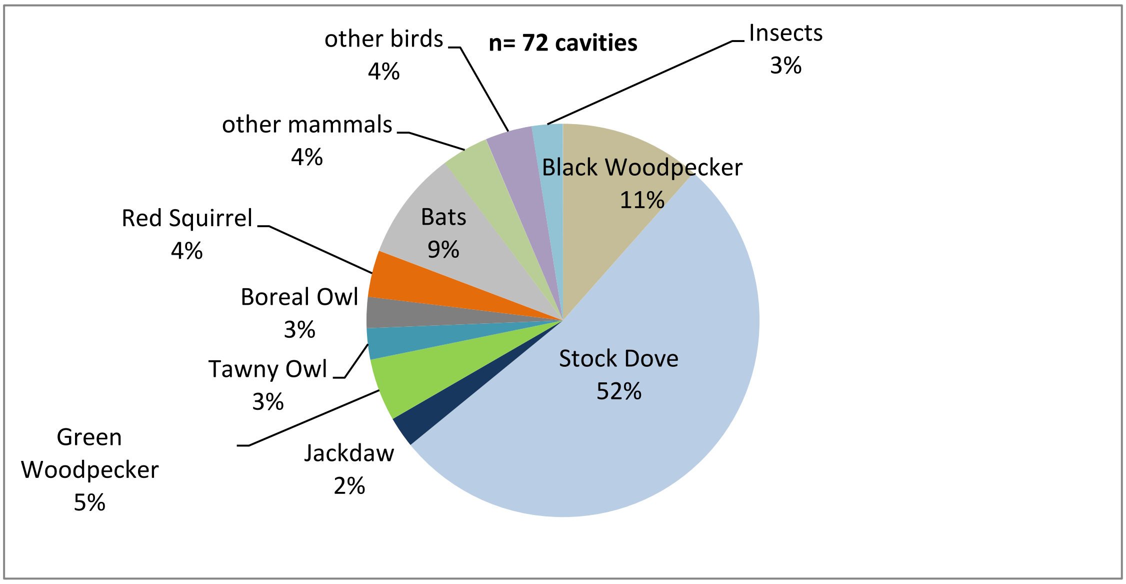


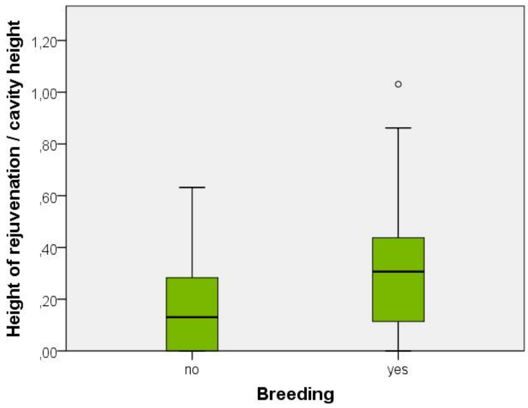
Figure 2: Animal community and the species share of black woodpecker cavities in the study areas.

52 cavities showed long term vertebrate activity such as nesting or roosting. We found that positively selected cavities were on average situated higher in the tree.

Preferred cavities showed a significantly higher rejuvenation in meter (selected mean= 3.9 m; SD= ± 3.03; SE= 0.43 /not selected mean= 1.9 m; SD= 1.97; SE= 0.43) MWU test (p= 0.01), and in percentage of cavity height (30% of cavity height in mean of preferred trees, SD= 0.24, SE=0.03/ 17% of cavity height in rejected trees; SD=0.24; SE= 0,04).

Predation events took more often place in lower cavities (mean= 12.1; SD=± 3.1; SE=0.98). Black Woodpeckers occurred at 9 cavities or 11% and stock dove at 44 cavities or 52%. Other cavity nesters (see Fig. 2) were different bat species, Green Woodpecker, Red Squirrels, Tawny Owl, Boreal Owl, Jackdaw and Dormice. Some of the chosen cavities showed more than one brood (Stock Dove).

Black Woodpeckers and Stock Dove showed similar preferences, however in some instances the Black Woodpecker appeared to be more pronounced (differences were not significant). Only one woodpecker nesting tree demonstrated no rejuvenation. Cavities with rejuvenation over 59% of the cavity height were avoided. The minimum distance between entrance and rejuvenation was 4.2 m. The Black Woodpecker was nesting in clusters of at least two cavities with one exception. The Stock Dove was nesting in a wider range of cavities. The height of rejuvenation ranged from 0 to 103% of the cavity height.



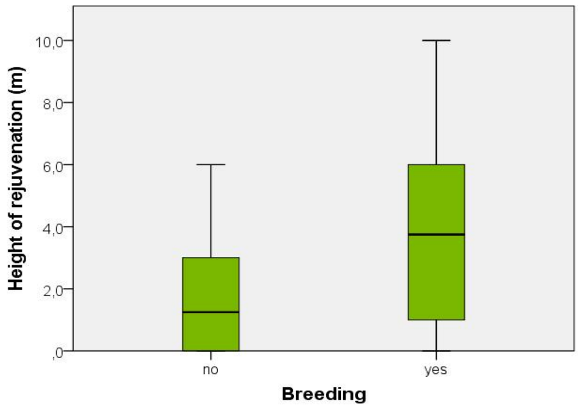


Figure 3: Rejuvenation in percentage of the cavity height **Figure 4: Cavities with rejuvenation (in m) were positively selected**

Predators and Predation events

Predators were detected in 45% of the cavities. We registered 7 predator species of which 3 were nocturnal (Pine Marten, Ural Owl, Tawny Owl) and 4 diurnal (Great Spotted Woodpecker, Common Buzzard, Northern Goshawk, Jay).

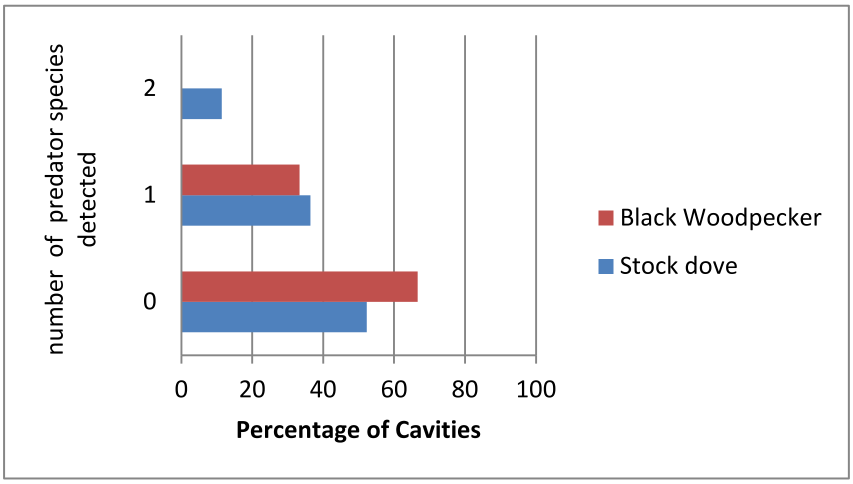


Figure 5: The number of cavities where predators were detected (Black woodpecker and Stock dove).

In six of the seven areas the Pine Marten was detected, in five areas the Great Spotted Woodpecker and the Common Buzzard were recorded, in three areas the Goshawk was registered, and the Ural Owl was only detected in the Bavarian Forest (in three cavities).

The pine marten appeared in one Black Woodpecker nest, four Stock Dove cavities, one Boreal owl nest and two unoccupied holes.

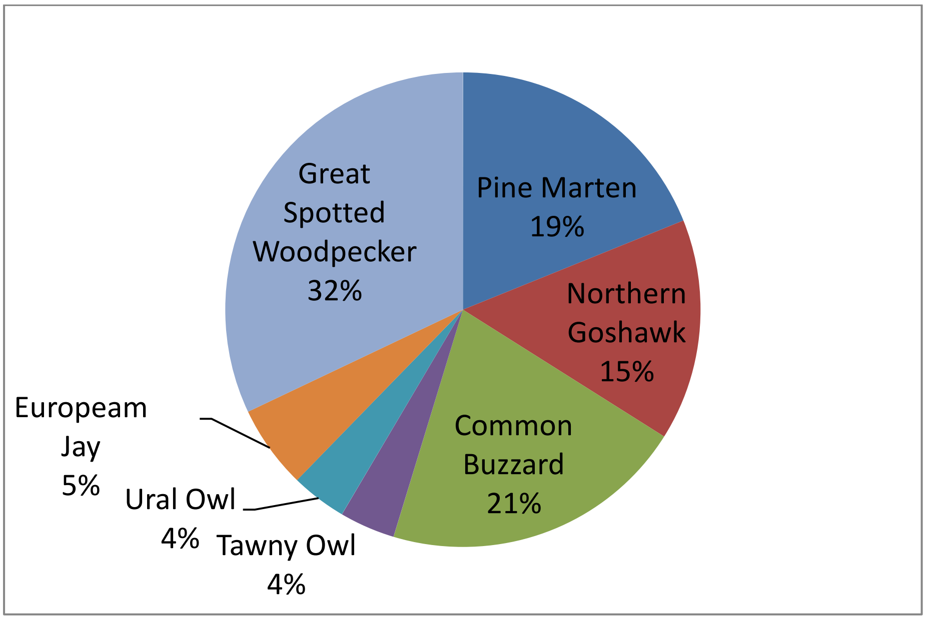


Figure 6: Percentage of potential predators recorded at cavity trees

Figure 7: Common Buzzards were by now unknown predators of cavities.

The most frequent avian predator was the Great spotted Woodpecker. This species visited 17 cavities inspecting the nests for eggs or small nestlings in early spring. The Great spotted Woodpecker frequently patrolled cavities only in five areas. It did not appear in the other two areas. The second most important predator was recorded to be the Common Buzzard (11 Cavities), followed by the Northern Goshawk (8 cavities) (Fig.6). The Northern Goshawk was only detected in cavity clusters, and in trees with large cavity heights (MWU test p= 0.03) and distances to the crown (MWU test p= 0.02). The Common Buzzard showed no significant pattern of depredation.

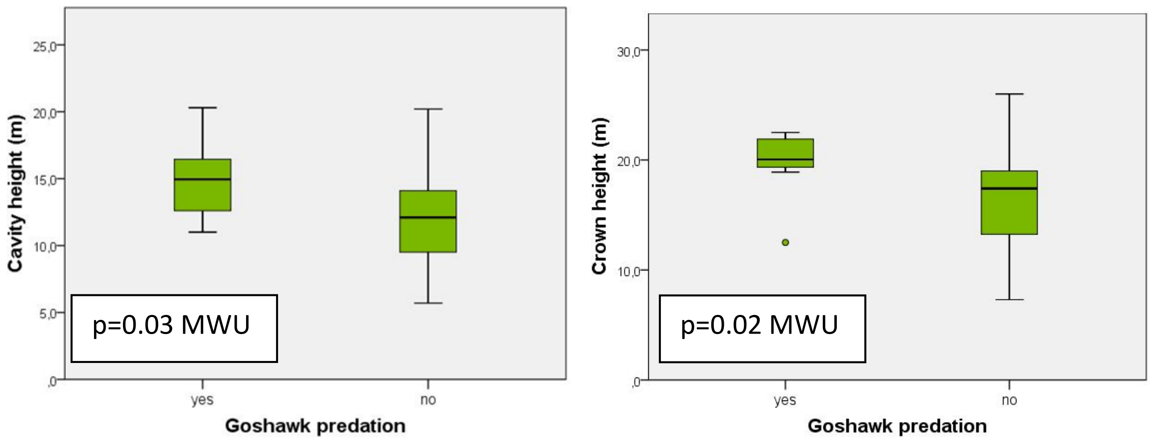


Figure 8: The Goshawk significantly selected the highest cavities with the largest distance to crown for depredation.

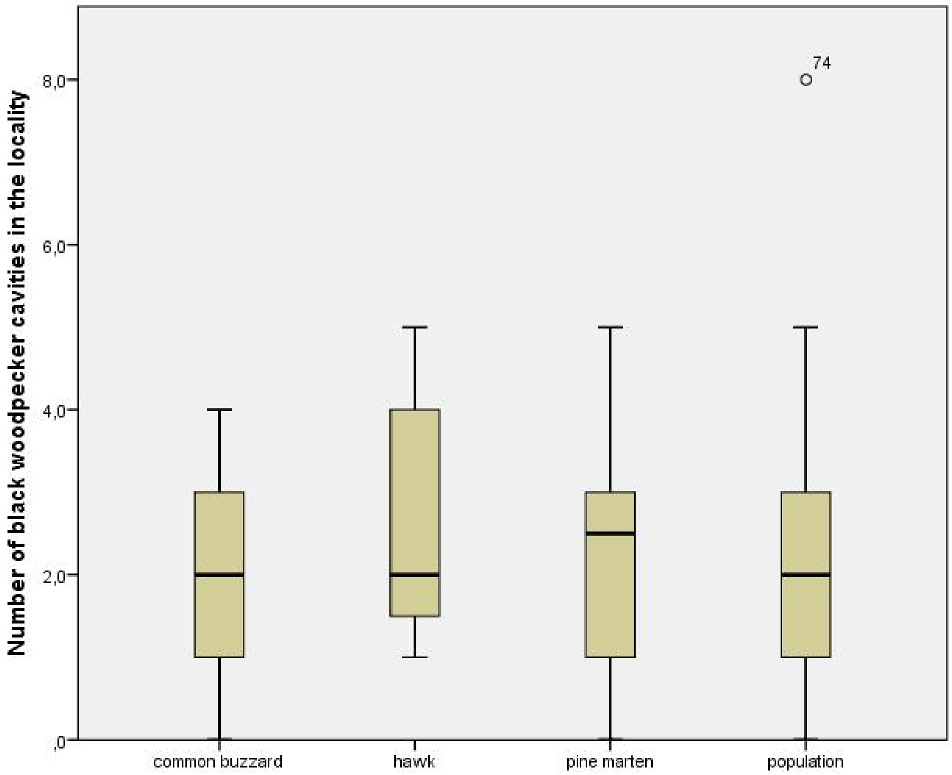


Figure 9: Preferences of predators recorded at single cavities or at cavity clusters

The Goshawk was only recorded in clusters of at least two cavities, while other predators occurred in all patterns of cavity distribution (Fig. 8).

The Jay has not been mentioned as a predator of Black woodpecker or Stock Dove nestlings. This species visited cavities with no evidence of success. It may however be a predator of eggs. It was detected in two areas with no evidence of predation.

Predators appeared at 47% of Stock Dove and of 33% of Black woodpecker nests. One predator per hole was detected in black woodpecker cavities, while in five Stock Dove cavities even two predator species were detected. Multiple predation events occurred in five cavities or in ten percent of all nesting trees.

Breeding as Response to Predation risk

Using multivariate statistics (Random Forests for classification, RF) we tested six traits of nesting cavities against unoccupied cavities regarding the breeding probability of Black Woodpeckers and Stock Doves. The traits included cavity type (single and group), cavity height, crown height, height of rejuvenation, social tree class (Kraft), and tree diameter in breast height. All together we classified 500 decision trees.

Appling multivariate statistics (Random Forests for classification, RF), we tested 6 traits (cavity type (single or group), cavity height, crown height, height of rejuvenation, social tree class (Kraft), tree diameter in breast height) of nesting cavities of Black woodpecker and Stock doves against unoccupied cavities about their breeding probability. All together we classified 500 decision trees.

For the validation of the multivariate model we used the out-of-bag error (OOB) estimation. OOB observations are a "built-in" test sample which ensures more realistic estimates of the error rate than the naive and over-optimistic estimates of the error rate resulting from predictions of the entire learning sample (Breiman 1996, Strobl et al 2009). The OOB estimate of error rate (i. e. the misclassification rate) was 28.17 % and therefore significantly smaller than the random misclassification rate of 50 % (p=0.019, chi-square test).

The relative importance of the observed predictor variables on classification was measured by mean decrease in accuracy (Breiman 2001, Cutler 2007, Bi 2012). In detail, this measure reveals the importance of a variable for distinguishing between breeding and non-breeding. Only three traits (cavity height, crown height, height of rejuvenation) turned out to be important for classification. For a deeper study of these three predictor variables we assessed partial dependence plots (Figure 9). Partial dependence is the dependence of the breeding probability on a predictor variable after averaging out the effects of all other predictor variables in the model. Thereby logits of the adoption probabilities are plotted on the y-axis and the scales of the predictor variables on the x-axis (Cutler 2007). In all three plots a relationship between the logit of the breeding probability and the predictor variable is obvious. The breeding probability increases when the height of rejuvenation increases. This means that caves with higher rejuvenation are preferred for nesting. In case of the cavity height we observed a similar effect. Higher caves are more likely to be incubated. However, at a cavity height of approximately 17 meters the breeding probability begins to decrease slightly. For crown heights less than 23 m a general tendency is not observable in the partial dependence plot. The breeding probability for trees with high crown heights (> 23 m) is very small.

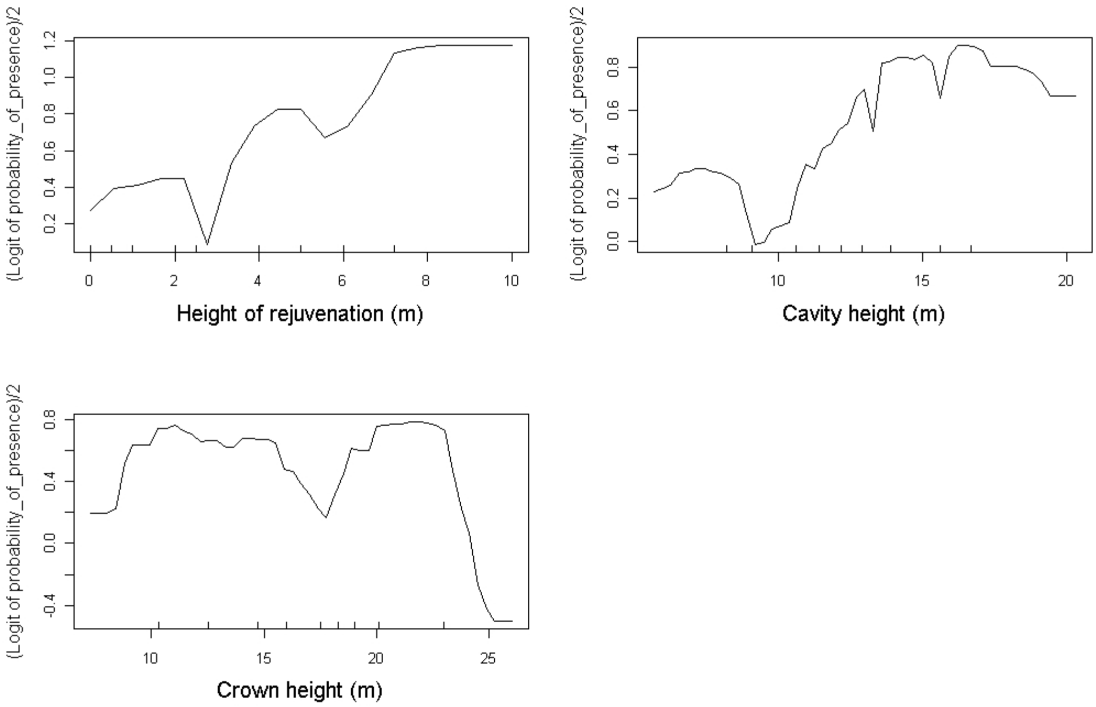


Figure 10: Random Forest Model (RFM) for the classification of the cavity selection by Stock Dove and Black woodpecker.

Discussion

The **spectrum of species** dwelling in large black woodpecker cavities conforms to other studies conducted in Germany (Lange 1993, Johnson et al 1993, Meyer 2001, Kaphegyi et al. 2009), with the Stock Dove reported as the dominant species. The method of investigating the cavities was different from all other European studies.

Is the predation observed in this study altered by the use of **camera traps**? In our study we found an average of 12% Predation rate of the pine marten. A study in Thuringia/Germany revealed an average of 13.5% nest failure in Black Woodpecker cavities (Black woodpecker 9% and 18% Stock Dove) (Lange 1993, Lange 1996). In Scandinavian forests with different tree species and lower cavity height the predation rate was up to 30% (Nilsson et al. 1993, Johnsson 1994, Rolstad et al. 2000). The pine marten was always described as the the main predator (Korpimäki 1987, Möckel 1988, Lange 1993, Jedrzejewska & Jedrzejewski 1998, Rolstad et al. 2000).

Compared to the depredation rate of Pine Marten in other cavity studies in Europe we have average to low depredation rate. This underlines that there was no pronounced change in predation because of camera traps. Weidingers study (2008) on open nesting song birds showed similar results where there was no increase in nest predation because of nest monitoring.

Does the type of stand or the **distribution** of Black Woodpecker cavities (evenly distributed, clustered or clumped) have an impact on the predation risk? Black woodpecker cavities were unevenly distributed due the inhomogeneity of forest age stages, tree age, tree dimension and species composition. The Black Woodpecker mainly nests in reproduction centers (Rudat et al. 1979, Kühlke 1985, Lange 1993). On average clusters of two cavities per reproduction center were recorded. 90% of all cavity trees were found in clusters of at least 2-3 trees and on average there were two to three cavity centers per Black Woodpecker territory (Kühlke 1985).

We found no evidence of predators preferring larger cavity centers, except for the Northern Goshawk hunting in clusters of at least two or more cavity trees. The reason for this observation may be that the Goshawk did not occur everywhere. Where it occurred this species was mainly observed in areas with small patches of beech with high concentrations of cavities in large stands of spruce.

No differences in predation risk were found between new and old cavities in our study. One reason may be that only a few new cavities were observed. In Finland a twenty year study with nest boxes (352 Boreal Owl nests) revealed that only 5 % of the Boreal Owl clutches were destroyed by Pine martens. The frequency of predation was independent of the nest box type, nest box age, nest density and success of the previous clutch in the box (Korpimäki 1987). According to Sonerud (1985, 1989) the predation risk increased with the age of the nest box. Anyway all studies revealed that the frequency of use decreased with an increase age of cavity or nest box age (Sonerud 1985, Korpimäki 1987, Möckel 1988, Lange 1993, Lange 1995, Meyer & Meyer 2004), but there are other factors too like the natural decay of the cavity or negative microclimatic aspects with deterioration in insulation.

Beech tree selection and predation risk

In Central Europe beech appears to be crucial as a cavity tree for the Black Woodpecker (Lange 1993, Kosinski & Kempa 2007), and other cavity dwelling species. Cavities are mainly situated on living trees and always on the tree trunk well below the start of the tree crown. In central Europe trees grow higher because of a longer vegetation period and better soils. The cavities of these trees are on average 12.3 m high in the tree. This has been confirmed by many authors (f.e. Lange 1993, Kosinski & Kempa 2007, Zahner et al. 2012). Black Woodpeckers nesting low in the tree is probably from a lack of a suitable high location (Gorman 2011). In Scandinavia, where beech is absent and the vegetation period is much shorter cavities are situated in other tree species and approximately 4 m lower in the tree (Johnson 1994, Rolstad et al. 2000). As primary cavity nester the Black Woodpecker directly chooses the nest site, is capable of maintaining cavities, and more often excavates a new cavity depending on the tree species. In Scandinavia the Black Woodpecker often nests in soft aspen or pine and therefore excavate nearly every year a new cavity (Rolstad et al. 2000, Gorman 2011). In the hard wood of beech only 10 to 50% of the population nests in new cavities (Rudat et al. 1979) with many being occupied for more than 5 to 7 years (Meyer 2001). Reuse is increased when the availability of appropriate substrate is lacking (Meyer & Meyer 2001).

In Eastern Poland the live span of Black Woodpecker cavities in pine trees over a thirty year study was on average 18 years. A German study (Meyer & Meyer 2001) revealed that 94% of beech trees were still usable after 24 years. In temperate European forests the Black Woodpecker nests nearly exclusively in beech. For many authors this strategy appears to be a behavioral response to minimize predation risk. Since Black Woodpeckers excavates cavities accessible to Pine Marten (*Martens martens*) the optimum protection strategy appears to nest in smooth barked trees (Kosinski & Kempa 2007). It is harder for the predator to climb on smooth bark and easier for the woodpecker to defend. We recorded several events where black woodpeckers actively defended their cavities against species like Red Squirrels or Stock Doves. (Rolstad et al. 2000) reported an attack of a cavity tree climbing Pine Marten on a defending black woodpecker. The Pine Marten did not investigate cavities higher than 15 m where 20% of the broods were found. Cavities situated higher revealed less predation events. This strategy appears to be successful. A Pine Marten was recorded in only one Black Woodpecker cavity. A polish study indicated that beech as a nesting tree could improve nesting success of Stock Dove and was therefore positively selected by this species (Kosiński et al. 2011). Predation rates on Stock Doves were higher in pine than in beech. The cavities used by the Stock Dove were situated higher than the unoccupied cavities (mean 11.8) (Kosiński et al. 2011). Cavities in beech trees improved nesting success. Therefore Stock Doves positively selected living beech trees. This supports our findings that Black Woodpeckers and Stock Doves were able to assess the predation risk and to react appropriate.

Behavioral patterns to reduce Predation risk

Risk of offspring predation is thought to be particularly important for the selection of nest sites (Fontaine & Martin 2006, Martin 1998, Kessler & Baldwin 2002, Blaustein et al. 2004). Females were able to asses nest predation risks. This suggests that predation risks characterize breeding activities in bird communities (Fontaine & Martin 2006). A number of studies recently showed that even short living passerine species were able to respond appropriate to predation threats f.e. warblers breaded higher up in the tree with a higher rodent population (Forstmeister & Weiß 2004).

Black woodpeckers are long living resident birds with a high learning ability and should demonstrate better adaptive behavioral responses by selecting saver cavities. This might be a trade-off between safety aspects (predation risk and risk of breakage) and energy costs of excavating new nest sites. Beech with smooth bark and a cavity high up in a tree trunk is saver in terms of depredation. Thick living hardwood beech does not break easily, however energy investment excavating a cavity is higher. These primary nesters show lower nest predation and a longer nesting cycle (Martin 1995). Excavating cavities higher up in the tree appears to be a response to decrease predation risks from the Pine Marten. The pine marten was present at most of the study sites (six out of seven). All other surveys dealing with nest losses in Black Woodpecker cavities stated Pine Marten as the main predator (Sonerud 1985, Korpimäki 1987, Möckel 1988, Lange 1993, Lange 1995).

Other than raptors the Pine Marten always causes a complete failure of the brood therefore considered as the most severe threat of Black woodpecker nests. The risk of predation by this predator can be reduced by adapted response strategies of the Black Woodpecker. A cover of beech rejuvenation in the vicinity of a cavity appears to makes it harder to find cavities due to our model. Pine Marten hunt mainly at night (Marchesi 1989, Stier 2012) when the fledglings are not being fed and do not attract attention. Cavities can be optically detected or from the scent. The higher the cavity and the higher the rejuvenation the more difficult it may be to detect. Black Woodpecker trees are the most dominant beech trees in the stand, with the highest social class, the largest diameter and a long limb free bole (Zahner et al. 2012). Without rejuvenation they are easy to detect. Nests may be additionally protected when the entire forest floor is covered with rejuvenation making it harder to find this cavity. Anyway Pine Marten have a searching image for this pattern because females give regular birth in Black Woodpecker cavities (Sonerud 1985, Korpimäki 1987, Marchesi 1989, Stier 2012) indicating that cavities are not only a hunting ground but also a space for reproduction.

This finding is different to observations in Thuringia in the 1990´s where 44% of all cavity trees were without rejuvenation (Lange 1995). This might be from former forestry practices when larger areas were harvested in a short period of time and beech did not have much rejuvenation time.

Even here the average height of rejuvenation in beech was 1.8 m with a maximum height of 15m. Several studies reported a preference of Black Woodpecker and Stock dove to free access not challenged by a layer of high rejuvenation (Möckel 1988, Lange 1993, Lange 1995). This does not contradict our findings. Does the rejuvenation get closer to the cavity entrance the harder it is to detect the Northern Goshawk, which may wait and ambush the adult bird. This species is a prominent predator for Black Woodpecker and Stock Dove (Möckel 1988, Gorman 2011). The Black Woodpecker which shows a high degree of plasticity is adaptive to new or changing environments. By the prediction of our model Black Woodpeckers prefer cavity trees with a certain amount of rejuvenation underneath with an average of 30% of the cavity height which appears to be a compromise between the predation risk of Pine Marten and Goshawk.

Once a predator appears at the cavity entrance the nestlings of the black woodpecker show several behavioral responses. Until the age of 18 days the nestlings start begging for food when there is scratching at the cavity tree and something is darkening the entrance (Meyer & Meyer 2004). At approximately 24 days the fledglings can glide out of the cavity if there is a hazard. This behavior may increase their chance of survival. This seems to be an appropriate response against raptor predation which only fish for nestlings in the deep cavity. Afterwards the fledglings are able to climb up a tree to flee predation from the forest floor.

There are two main passive strategies for cavity tree selection: to frequently change the cavity by excavating new ones or to nest high up in smooth barked beech. If the Black Woodpecker has a choice it will select beech. There are several behavioral responses to depredation. Adult birds actively defend the nests by attacking the intruder, and depending on age the nestlings hide or escape.

Adult Black Woodpeckers appear to reduce their predation risk by often sleeping in cavities with a second entrance used as a nocturnal roosting place, and by hanging on the cavity walls. Once a Pine Marten appears it might have a chance to escape. Cavities with a second entrance were not used by the Black Woodpecker as nesting trees in this study. This finding was confirmed in Thuringia were Black Woodpecker also only nested in intact cavities with no additional entrance (Lange 1993). The reason for that may be from negative microclimatic aspects (Lange 1996).

The situation in Stock Dove is different. Broods were frequently recorded in cavities with two entrances. This is confirmed by a large study with 197 cavities in Thuringia where 40% of Stock Dove nest sites had a second entrance. In a polish study the Stock Dove even preferred cavity trees with two or more entrances (Kosiński et al. 2011).

Over years Black Woodpeckers are more likely to excavate new cavities in cavity centers which are the core areas of the Woodpecker territory (Lang & Rost 1990). Kosiński et al. (2010) reported a strong correlation between the cavity densities with the density of the black Woodpecker. The abundance of black woodpecker and Stock Dove is increasing with the amount of beech stands older than 100 years. And the Stock Dove is strongly positive correlated with the number and availability of black woodpecker cavities (Kosinski et al. 2010).

In Sweden a lower predation rate was observed as there were only one or two cavities within 50 m (Johnsson 1993). We could only confirm this observation for the Northern Goshawk.

In our study we found only 4% of all cavities with no visitation. On average 2.9 species were detected at a cavity excluding predators. This high rate of species visitations along with the aggressive interaction between species suggests cavities to be a limiting factor. This **limitation of suitable cavities in managed forests** is indicated by several studies in Central Europe (Möckel 1988, Lange 1993, Kosiński & Kempa 2007, Kosiński et al. 2011). In Thuringia Black Woodpeckers continuously used on average one cavity for only 1.8 years. This relatively short time does not correspond with a high rate of new excavations (rate of 0.1 to 0.2 per year) (Kühlke 1985, Lang & Rost 1990, Kosiński & Kempa 2007). In contrary the Black Woodpecker returns to a previously excavated cavity (Kühlke 1985). Kühlke (1985) suspect that the short time spent in a cavity is from strong competition between the Black Woodpecker and secondary cavity nesters. This study demonstrated that Black woodpeckers are very successful in defending its nesting cavity. There was no case recorded of another species displacing the woodpecker. The regularly change of cavity appears to be a question of predation. Hypotheses that the frequent change of cavities is due to parasites are unlikely because the survival rates without predation ought to have reduced brood size or nestlings weight in old nests. However no such effects were found (Nilsson et al 1991).

Breeding in old cavities is not only because of the lack of potential cavity trees. Black Woodpeckers are also constrained by time in spring (Nilsson et al 1991). Early breeding seems to be very important for the recruitment of fledglings to the breeding population (Nilsson et al 1991). They choose to breed early in an old instead of late in a new cavity. Breeding is advanced by using an old cavity (Nilsson et al 1991) and energy is saved for the laying of eggs and for breeding.

Further reasons for the low numbers of cavities and a strong competition is the small number of pairs per 100 ha (0.8-1.8) (Kühlke 1985, Kosiński & Kempa 2007, Cockle et al. 2011, Wesołowski 2007), and the territorial behavior of the Black Woodpecker. The mean distance between two active nest sites in Central Europe is approximately 0.9 km (0.4 -1.6 km) (Bocca & Ronaldo 2003, Kosiński & Kempa 2007). As mentioned before the lack of cavities does not appear to accelerate the excavation rate, but rather to extend the use of the nest site (f.e. Kühlke 1985, Lange 1993). The distribution of cavities is affected by the pattern of old beech stands on a landscape level (which is a trait of forestry). Kühlke (1985) pointed out that the age of the selected cavities was younger than the average of all the cavities. Regarding to that, the succession of cavities with a deeper bottom makes them less attractive for the black woodpecker.

The Stock Dove as a secondary cavity nester shows a higher predation rate as it is predicted by models (Fontaine 2006). The reasons are the poorer cavity conditions if not maintained by the black woodpecker. Water can intrude if the callus of the cavity entrance is not removed. Nevertheless, nest failure is remarkably higher compared to that of the Black Woodpecker. Great Spotted Woodpecker and sometimes Black woodpecker destroy the clutch of the Stock Dove (Lange 1993, Kaphegyi et al. 2009) and one reason for that. The Great spotted woodpecker uses the eggs as a food source. Direct confrontation with the black woodpecker, the Stock Dove did not succeed in this study. These results are confirmed by other surveys in central Europe where eggs of the Stock Dove were pierced or were killed (Lange 1993, Kaphegyi et al. 2009).

The Stock Dove is an important prey species to the Goshawk. This also might have a high impact on adult survivorship and fledgling rate (Möckel 1988). To compensate for the low number of nestlings and the high predation rate this species has successional broods and needs a higher number of cavities in a reproduction center (Möckel 1988). With the ability to construct branch nests even older and less attractive cavities are appropriate nest sites. In central Europe they have four and in Western Europe up to five broods per year (Möckel 1988). With this strategy it uses cavities longer in the seasons when no larger and powerful competitors are breeding. With direct competition the Stock Dove pair is very persistent and competitive. The pair often succeeds in gaining a cavity by outcompeting other bird species. This study revealed a tawny owl driven away from its clutch while no Stock dove lost a taken cavity. This may explain why 51% of all cavities were occupied by Stock Doves. Möckel (1988) found an occupancy rate of 33.7%. In several other studies the Stock Dove is also the most frequent user of this type of cavity (Meyer & Meyer 2001).

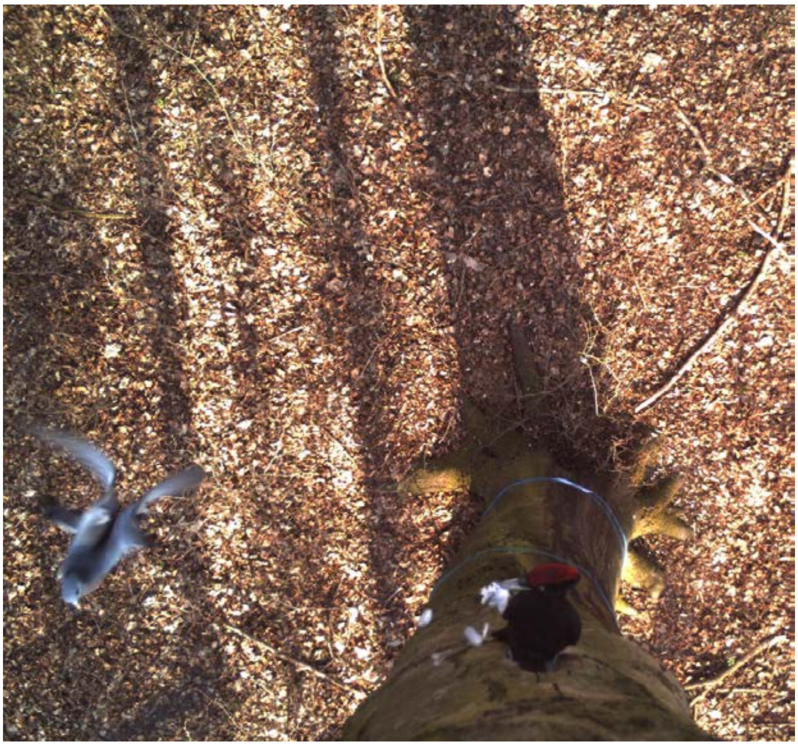


Figure 11: Black Woodpeckers were able to defend their cavities against secondary cavity users like the Stock dove.

In our study the Great Spotted Woodpecker visited 32% of all cavities and was the most common nest predator. Because of its small size it is not able to prey on larger nestlings like Stock Dove or Black Woodpecker. It may however be a successful predator of eggs. Camera traps in Norway detected Great Spotted Woodpeckers even preying on Capercaillie clutches, and a study in the Czech Republic observed 7% of open nesters depredated by this species (Weidinger 2009) even up to thrush size.

The Goshawk is a threat to adult Black woodpeckers and Stock Doves which contributes circa 1% of its prey. High rejuvenation of beech could be a risk. Avoiding predation of this raptor they have to have a good overview out of the cavity and a quick approach to the cavity. This may explain the optimum curve of rejuvenation height. The black woodpecker avoided nest sites over a maximum of 59% of the cavity height. The distance to rejuvenation was at least 4 m. The Stock Dove was more flexible and inhabited cavities with a rejuvenation which almost was as high as the cavity.

Raptors such as Goshawks and Common buzzards are larger in size and therefore a smaller threat to nest predation. Fishing for the nestlings or fledglings in the cavity is partial predation which does not question nesting success.

No predation of Black Woodpecker cavities by Common buzzards and Goshawks has been documented by now. In central Europe the Goshawk is a specialized bird predator with 81-86% birds in its prey, (Jedrzejewska &Jedrzejewski 1998) while the common buzzard is considered a rodent predator. In Bialowies Forest the Common Buzzard is the most important predator of birds in spring and summer, catching predominantly fledglings (Jedrzejewska & Jedrzejewski 1998). During this time of the year an average of 34% of its prey biomass include birds. In Bialowies the predation rates on birds were consistent from one year to another. The Common buzzard has not been documented as a cavity predator. This species is an open nest predator and was observed at 7% of all monitored nests (camera traps) by a study conducted in the Czech Republic (Weidinger 2009). The prominent decrease of meadows and grassland due to increasing corn production for renewable energy in central Europe may cause the Common Buzzard hunting in the forests with different prey species. This prey switching behavior may reveal nestlings in cavities as a new food source. This question should be addressed with additional research. Tawny Owl predation rates on birds vary with rodent population. Wesolowski (1995) observed for blackbird as open nester as well as for the white-backed woodpecker a higher predation rate in Bialowies forest if there was a lower number of rodents. This prey switching is a wide spread phenomena which could be another reason for observed behavior of Common Buzzard in this study.

Forest Management

There is a need to understand the complex relationship between forest management and the decline of biodiversity. The protection of cavity trees and potential cavity trees which are old enough to be infected by a heart rot is only one aspect.

Strategies of Black Woodpeckers in temperate beech forests (Central Europe) are different than in other tree species. It is a high energy investment and benefits for the individuals are only recognized after a long term occupation of the cavity. The predation risk is a main aspect considered by excavating cavities high in smooth barked trees and not by frequently changing cavities.

Beech plantations with a reduction of trees per ha (60 instead of 80) to increase growth and concentrate biomass to a smaller number of trees will decrease the length of the tree trunk and increase the amount of rejuvenation because of additional light exposure. Early harvest will decrease the number of trees with heart rot as it is a function of age (Zahner et al. 2012). This may result in a decrease of sites for the Black Woodpecker affecting the whole community of cavity dwellers (Kosinski & Kempa 2007). On the other hand this study revealed that the stage in which a cavity is suitable despite rejuvenation is more extended than expected and predicted by other authors (Möckel 1988, Lange 1993, Lange 1995)

In consequences forest management that complies biodiversity aspects has to keep reproduction units (cavity clusters) of old beech patches available where the rejuvenation is suppressed by a minimum of light until the black woodpecker can take advantage of other areas of the forest district to excavate new cavities. In average a Black Woodpecker territory has 2.5 cavity centers (Kühlke 1985). As a management goal there should be at least one active reproduction center (cavity center) of the Black Woodpecker on a landscape level of 1-3 Square Kilometer.

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Attachments: Images of the camera trap

Figure 12: Tawny Owl visiting the same cavity tree with Stock Dove as the Common Buzzard did earlier in the year.

Figure 13: The most frequent and severe predator of losing a clutch is the Pine Marten.

Figure 14: The Northern Goshawk was only detected in two study sites.

Figure 15: There is intensive competition for the large cavities. Here a Black Woodpecker defends its nest against a red squirrel, which has nest material in its snout (white arrow).

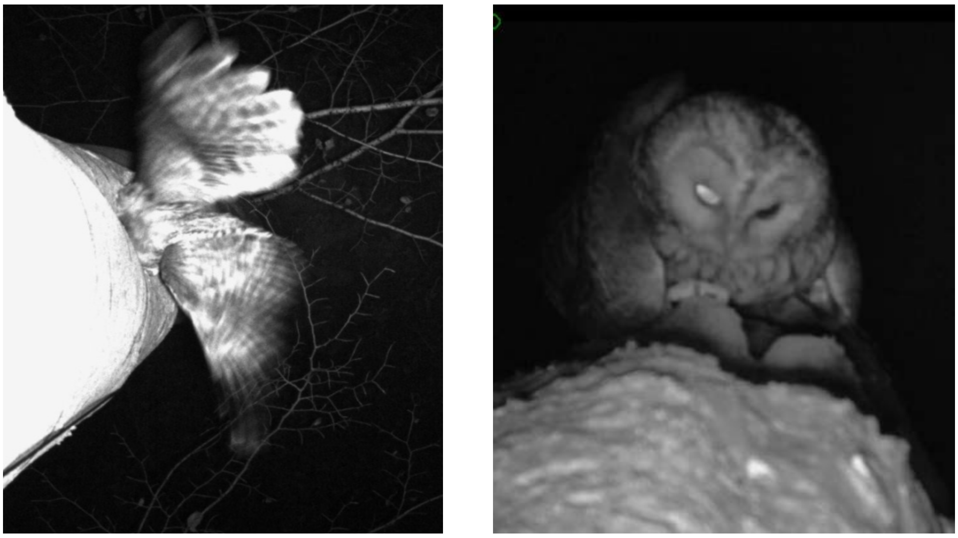

Figure 16: The number of nocturnal predators is almost the same (here Ural Owl and Tawny Owl) as the diurnal ones.

Tab. 1: Data set of the 72 cavity trees and their dwellers.

ID	ID_NR	Bestand	Besuchs-rate	Y_Brüter	Hoehlenschläfer	Y_Predator
1	Bad Rodach-1	Ei, Bu	3	Hohltaube	Schwarzspecht, Grünspecht	Mäusebussard
2	Bad Rodach-2	Ei, Bu	2	Eichhörnchen	Grünspecht	Baummarder
3	Bad Rodach-3	Ei, Bu mit Bi u Fi				-
4	Bad Rodach-4	Ei, Bu, Li	1	Eichhörnchen		Mäusebussard
5	Bad Rodach-5	Ei, Bu, Li	2	Schwarzspecht, Hohltaube	Schwarzspecht (parallel zur Ht)	Waldkauz
6	Bad Rodach-6	Bu, Ei u SLh	2	Hohltaube (2x)	Schwarzspecht	Baummarder, Mäusebussard
7	Bad Rodach-7	Bu, Ei u SLh	2	Hohltaube	Schwarzspecht	-
8	Bad Rodach-8	Ei, Bu	2	Hohltaube, Schwarzspecht	Schwarzspecht	Mäusebussard, Waldkauz
9	Bad Rodach-9	Bu, Ei u SLh	2	Waldkauz, Hohltaube (2x)	Schwarzspecht (parallel zur Ht)	Waldkauz
10	Bad Rodach-10	Ei, Bu	3	Schwarzspecht, Waldkauz, Hohltaube		
11	Bay. Wald-1	Bu mit Fi				-
12	Bay. Wald-2	Bu mit Fi				-
13	Bay. Wald-3	Bu-Fi	1	Raufußkauz		Baummarder
14	Bay. Wald-4	Fi-Bu-Bah				-
15	Bay. Wald-5	Bu-Fi-Bah	1	Hohltaube		-
16	Bay. Wald-6	Bu-Fi	1	Hohltaube		Habichtskauz, Mäusebussard
17	Bay. Wald-7	Bu-Fi	2	Hohltaube (2x)		Mäusebussar
18	Bay. Wald-8	BMW				Baummarder
19	Bay. Wald-9	Fi-Bu-Ta				Habichtskauz
20	Bay. Wald-10	Bu	3	Dohle, Hohltaube		Habichtskauz
21	Freising -1	Bu-Ei	1		Grünspecht	
22	Freising -2	Bu-Ei	1	Hohltaube		Baummarder
23	Freising -3	Bu-Ei	4			
24	Freising -4	Bu-Ei	3		Buntspecht	
25	Freising -5	Bu-Ei-Bah	5			
26	Freising -6	Bu-Ei-Bah	1		Buntspecht	
27	Freising -7	Bu-Ei-Bah	3	Hohltaube		
28	Freising -8	Bu-Ei	6			
29	Freising -9	Bu-Ei	6	Hohltaube	Schwarzspecht	
30	Freising -10	Bu-Ei	5			
31	Freising -11	Bu	2	Hohltaube		
32	KEH-1	80Bu 20Fi+Ei+Lä	1			Baummarder
33	KEH-2	80Bu 20Fi+Ei+Lä	1		Hohltaube	
34	KEH-3	100Bu	2	Hohltaube	Schwarzspecht	
35	KEH-4	100Bu	1		Hohltaube	
36	KEH-5	100Bu mit Fi Horst	1	Hohltaube		Baummarder
37	KEH-6	50Ei 50 Bu	2	Schwarzspecht	Hohltaube	
38	KEH-7	60Ei 40Bu	2	Schwarzspecht	Hohltaube	Baummarder

ID	ID_NR	Bestand	Besuchs-rate	Y_Brüter	Hoehlenschläfer	Y_Predator
39	KEH-8	50Es 20Bu 30 Ei	2		Schwarzspecht, Hohltaube	
40	KEH-9	50Es 30Bu 20 Ei	1	Hohltaube		
41	KEH-10	70Ei 30 Bu	1	Hohltaube		
42	Ebrach Süd-1	Bu-Ei-Ki	4	Hohltaube	Taube, Fledermaus, Eichelhäher	
43	Ebrach Süd-2	Bu-Ei-Ki	2	Hohltaube	Taube, SchwSp	Habicht
44	Ebrach Süd-3	Bu-Ei	1	Hohltaube	Taube	
45	Ebrach Süd-4	Bu-Ei	3	Hohltaube	Taube, SchwSp, GrünSp, Waldkauz	Waldkauz
46	Ebrach Süd-5	Bu-Ei-Ki	3	Hohltaube	Taube, SchwSp, BuntSp, Waldkauz	Habicht
47	Ebrach Süd-6	Bu-Ei	2	Hohltaube	Taube, Fledermaus	
48	Ebrach Süd-7	Bu-Ei	5	Hohltaube	Taube, SchwSp, BuntSp, Kohlmeise, Fledermaus	
49	Ebrach Süd-8	Bu-Ki	2	Hohltaube	Taube, SchwSp	
50	Ebrach Süd-9	Bu-Ki	1	Hohltaube	Taube	Mäusebussard
51	Ebrach Süd-10	Bu-Ki	4	Hohltaube	Taube, BuntSp, Kohlmeise, Eichelhäher	Mäusebussard
52	Ebrach Nord-1	Ei-Bu (HBu)	5	Schwarzspecht	Taube, SchwSp,BuntSp, GrünSp, Habicht	Habicht
53	Ebrach Nord-2	Ei-Bu (HBu)	2	Hohltaube	Taube,BuntSp	Habicht
54	Ebrach Nord-3	Bu-Ei (Fi)	6	Schwarzspecht	Taube, SchwSp,BuntSp, Kohl-, Blaumeise, Eichhörnchen	
55	Ebrach Nord-4	Bu-Ei (Fi)	3	Hohltaube	Taube, BuntSp, SchwSp,	
56	Ebrach Nord-5	Bu-Ei	3	Hohltaube	Taube, BuntSp, Eichelhäher	
57	Ebrach Nord-6	Bu-Ei (Fi)	3	Hohltaube	Taube, SchwSp,BuntSp,	
58	Ebrach Nord-7	Bu (Ei)	2	Hohltaube	Taube, BuntSp,	
59	Ebrach Nord-8	Bu (Ei)	1	Hohltaube	Taube	Baummarder

ID	ID_NR	Bestand	Besuchs-rate	Y_Brüter	Hoehlenschläfer	Y_Predator
60	Ebrach Nord-9	Bu (Ei)	1	Raufußkauz		
61	Ebrach Nord-1	Bu (Ei)/Lä-Ki	4	Hohltaube	Taube, SchwSp, Fledermaus, Waldkauz	Habicht, Mäusebussard
62	Ebrach Nord-1	Bu (Ei)/Lä-Ki	3	Schwarzspecht	Taube, SchwSp,	
63	Schongau-1	Fi-Ta-Bu	4	Hohltaube	Taube, BuntSpecht, SchwarzSpecht, Kleiber	
64	Schongau-2	Fi-Ta-Bu	2	Schwarzspecht	Taube, SchwarzSpecht,	
65	Schongau-3	Ta-Bu-Fi innige Mi	4	Hohltaube	Taube, BuntSpecht, SchwarzSpecht, Grauspecht, Fledermaus	
66	Schongau-4	Fi-Bu	5	Hohltaube	Taube, Buntspecht, Schwarzspecht, Waldkauz, Fledermaus	
67	Schongau-5	Bu (Ta-Fi)	5	Hohltaube	Taube, SchwarzSpecht, Buntspecht, Grauspecht, Waldkauz, Baummarder	Baummarder
68	Schongau-6	Lockerer Bu Althol	5	Hohltaube	Taube, SchwarzSpecht, Buntspecht, Kleiber, Kohlmeise, Mäusebussard	Mäusebussard
69	Schongau-7	Lockerer Bu Althol	3	Hohltaube	Taube, SchwarzSpecht, Buntspecht, Mäusebussard, Habicht	Mäusebussard, Habicht
70	Schongau-8	Fi-Bu (Ta)	5	Hohltaube	Taube, SchwarzSpecht, Buntspecht, Fledermaus, Waldkauz, Habicht	Habicht

ID	ID_NR	Bestand	Besuchs-rate	Y_Brüter	Hoehlenschläfer	Y_Predator
71	Schongau-9	Fi-Bu (Ta)	4	Hohltaube	Taube, Schwarzspecht, Buntspecht, Fledermaus, Habicht	Habicht
72	Allershausen_1	Bu	4	Hohltaube	Schwarspecht, Grünspecht, Tannenmeise	