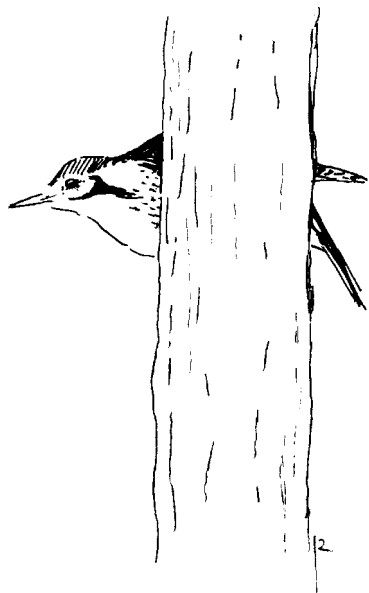


CHARACTERISTICS OF TREES PREFERRED BY FORAGING MIDDLE SPOTTED WOODPECKER *DENDROCOPOS MEDIUS* IN NORTHERN SWITZERLAND

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The endangered Middle Spotted Woodpecker *Dendrocopos medius* is restricted to oak forests. We analysed this woodpecker's foraging trees and behaviour in a coppice-with-standards wood in the Swiss lowlands. Oaks *Quercus* spp. were highly preferred and their diameter at breast height mainly ranged from 36-72 cm, corresponding to an age of > 120 years. Over 78% of the foraging observations were made in oak crowns, and among these, medium-sized were used most frequently. Regarding their contacts with adjacent ones, the birds preferred crowns with none or one contact, whereas those with ≥ 3 contacts were avoided. Dead trees were used randomly for foraging and, within a tree, only 122 out of 436 foraging observations were made on dead substrate. Searching and probing were the most frequently observed foraging techniques. For the support of this species, a long-term management of moderately harvested forests containing old oaks is needed.

Key words: *Dendrocopos medius* - oak habitat - foraging behaviour - forest management

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INTRODUCTION

In central Europe, the occurrence of the Middle Spotted Woodpecker *Dendrocopos medius* is determined by the presence of oak *Quercus* spp. (Winkler *et al.* 1995). Forest size and oak density are important factors, influencing distribution and population size of these birds (Müller 1982, Pettersson 1985). The species reaches its highest breeding density in hardwood rich in oak where it can be even more abundant than the Great Spotted Woodpecker *Dendrocopos major* (Lovaty 1980, Wesołowski & Tomiałojć 1986). Orchards or forests with few oak are occasionally colonized if they border on woods rich in oak (Winkler *et al.* 1995). The association with oak forest could be based on the bird's foraging preference (Jenni 1983). Analysing foraging sites on oaks in Swe-

den, Pettersson (1983) found arthropod taxa occurring on various tree species, but none solely attributed to oaks. Obviously, the preference is not explained by the presence of specific arthropod taxa on which the woodpecker needs to feed. However, the arthropod richness of oaks is well-known (Southwood 1961, Nicolai 1986), and therefore, high abundance of food is the most probable reason for their preference. Although the importance of oak is evident, data on the properties of oaks (e.g. diameter or crown structure) are still lacking. The present knowledge is derived indirectly from census data (e.g. Günther 1992, Schmitz 1993). Such large-scale studies cannot reflect sufficiently the importance of particular habitat structures. The main purpose of this study is therefore to determine the characteristics of trees preferred by foraging Middle Spotted Woodpeck-

ers. As populations of this species are in decline in many parts of its range (Böhning-Gaese & Bauer 1996), such data are urgently needed in order to develop management strategies.

STUDY AREA AND METHODS

The study was conducted in an 800 ha forest, 30 km north of Zürich near the Rhine river (47°37'N, 8°37'E; 380 m a.s.l.). This forest is an important breeding area for the Middle Spotted Woodpecker with up to 60 breeding pairs and consists of deciduous wood in 42.5% (323 ha) of its area. Oak and Scots Pine *Pinus sylvestris* are the dominant tree species on 34.1% (259 ha) and on 30.4% (231 ha) of the area, respectively, whereas Spruce *Picea abies* and Silver Fir *Abies alba* cover 24.5% (186 ha). Within this forest we chose a 40 ha plot, in which a preliminary census had shown a breeding density of 2.4 pairs per 10 ha for the Middle Spotted Woodpecker (Bühler unpubl. data). The study plot is a typical oak-hornbeam forest (*Galio silvatici-Carpinetum*), managed for centuries as coppice-with-standards. Oak density reaches 133 stems ha⁻¹.

We determined the availability of tree species with data obtained by ourselves and from an inventory of the Forestry Service. At the intersections of an 80 × 150 m grid we located circular plots of 300 m². Within these circles, we recorded species and diameter of all trees with diameter at breast height (*dbh*) ≥ 8 cm. For subsequent analyses, we categorized the trees into six classes (8-16 cm, 16-24 cm, 24-36 cm, 36-52 cm, 52-72 cm, ≥ 72 cm *dbh*).

We described tree crowns forming the canopy with crown length (long: crown length ≥ 1/2 tree length; medium-long: 1/4-1/2 of tree length; short: < 1/4 tree length), and crown breadth (broad: crown breadth ≥ crown length; medium-broad: ≥ 1/2 crown length; narrow: < 1/2 crown length). Then we defined three crown sizes as a combination of crown length and breadth: large crowns: long & broad, long and medium-broad, medium-long and broad; medium sized crowns:

long and narrow, medium-long and medium-broad, short and broad; small crowns: medium-long and narrow, short and medium-broad, short and narrow. Further on, we counted the contacts of the crown with adjacent crowns (five categories: 0, 1, 2, 3 and ≥ 4 contacts). This represents an indirect measure of sunlight reaching the crown, as crowns with more contacts receive less sunlight than those with none or few contacts.

Data on foraging behaviour were obtained in 1991 and 1992 from January-June both from unmarked and four marked individuals. We described foraging behaviour with instantaneous sampling with an interval of 30 s (Altmann 1974). At each sample point, we recorded the position within a tree (stem or crown), the condition of the foraging substrate (alive or dead), and the foraging technique of the focused bird (probing: bill or tongue used to forage inside the substrate; pecking: bill hits the substrate to excavate subsurface food items; gleaning: picking food items from the substrate surface; sapsucking: taking up sap; flycatching: catching a flying object as Flycatchers do; searching: climbing on a stem or branch after and before using another foraging technique). A bird was recorded until it disappeared, what we considered to be a sequence. Thereafter, we recorded species, condition, *dbh* and crown type of each tree used.

In all analyses we accepted only the first observation per tree. We got 170 sequences referring to 436 trees. Three-quarters of these sequences furnished ≤ 3 foraging trees, and less than 7% contained ≥ 6. From a statistical point of view, such sequential observations are likely to be dependent, and only the first observation (or the first after a fixed time interval) is usually considered for analysis (e.g. Heijl *et al.* 1990). Biologically, sequential observations take into account rarely used and/or inconspicuous resources (Raphael & White 1984) and yield important insights into the behaviour of foraging birds (Noon & Block 1990). Of the 436 foraging observations, 37% were made on the four marked birds. These data were analysed for each individual (following Thomas & Taylor 1990), and compared to the available re-

sources estimated from the circular plots in its home range. Observations on unmarked individuals were pooled and treated as one further individual. In this case we estimated availability using all circular plots within the study area. Following Allredge & Ratti (1986), we applied the Friedman test to determine whether differences between selection and availability were the same for all resources (H_0). If this test resulted in rejection of H_0 , we calculated Bonferroni's simultaneous confidence intervals to determine which resources were being preferred (Byers *et al.* 1984).

RESULTS

Most woodpeckers (78-95%) were observed foraging in crowns, and the birds used mainly living substrate (72% of 436 observations; Fig. 1). Only one individual foraged almost as often on dead (48%) as on living substrate. The main foraging techniques were searching and probing (Fig. 2), both contributing > 73% to all observations. Pecking was recorded much less frequently (< 17%) and gleaning and sapsucking occurred only occasionally.

Tree species were not used according to their availability (Friedman test, $T = 27.3$, $df = 6$, $P < 0.001$). All woodpeckers preferred to forage on

oaks (Table 1): The four marked individuals used them in > 90% of the observations, the unmarked ones in 76%. Besides oak, maple was used regularly, but only the unmarked woodpeckers selected it more often than expected. Other tree species used were Spruce and Scots Pine, both less than could be expected. Regarding the condition of trees, the woodpeckers selected at random (Friedman test, $T = 0.20$, $df = 1$, $P > 0.6$); they rarely (< 5%) foraged on dead trees.

In the following analyses, we considered only oaks because these were so strongly preferred.

Oaks of different *dbh* were not used according to their availability (Friedman test, $T = 15.04$, $df = 4$, $P < 0.01$). Oaks smaller than 36 cm were generally avoided (Table 2). Those with 36-52 cm were visited frequently (significant for one individual). Those with 52-72 cm were significantly preferred by two individuals and the unmarked ones, whereas larger oaks (≥ 72 cm) were used as expected or even avoided.

Oak crowns were used in accordance to their availability (Friedman test, $T = 0.40$, $df = 2$, $P > 0.8$). Over 60% of the foraging observations of four individuals were made in medium-sized crowns, and both large and small ones were of minor importance (< 31% and < 9%, respectively). The behaviour of the unmarked individuals deviated from this pattern because large

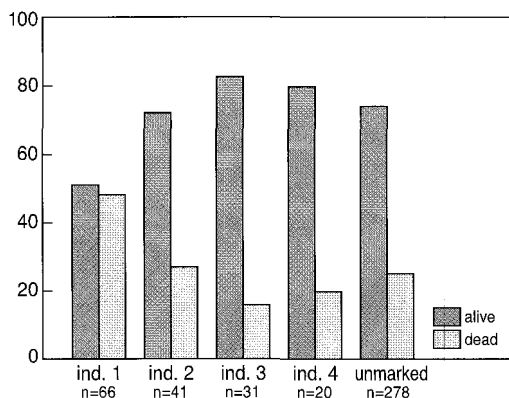


Fig. 1. Condition of substrate used by the Middle Spotted Woodpeckers (n : number of observations).

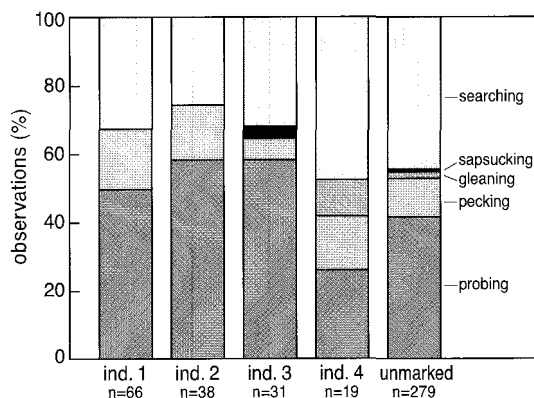


Fig. 2. Foraging techniques of the Middle Spotted Woodpeckers (n : number of observations).

Table 1. Tree species used by the Middle Spotted Woodpeckers. 'A': availability in %; 'U': use in %. Remaining hardwood: Common Maple *Acer campestre*, lime *Tilia* spp., cherry *Prunus* spp. Remaining conifers: Larch *Larix decidua*, Silver Fir *Abies alba*. *n*: number of trees. Unmarked: pooled unmarked individuals. Differences between A and U tested by Bonferroni's simultaneous confidence intervals: '+' : positive selection, preference ($P < 0.05$); '-' : negative selection, avoidance ($P < 0.05$); no sign: no selection.

Tree species	Ind.1		Ind.2		Ind.3		Ind.4		Unmarked	
	A	U	A	U	A	U	A	U	A	U
Oak	19.0	90.9+	19.0	95.4+	12.1	94.1+	16.4	100.0+	16.3	75.7+
Hornbeam	62.0	1.5-	62.0	0.0-	55.8	0.0-	57.8	0.0-	59.0	1.8-
Maple	1.1	3.0	1.1	4.6	0.1	5.9	0.6	0.0-	0.7	18.5+
Remaining hardwood	8.4	0.0-	8.4	0.0-	16.0	0.0-	15.8	0.0-	12.7	0.0-
Spruce	0.0	0.0	0.0	0.0	9.1	0.0-	7.7	0.0-	4.8	1.1-
Scots Pine	9.5	4.6	9.5	0.0-	6.9	0.0-	0.6	0.0-	6.2	2.9-
Remaining conifers	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0-	0.3	0.0
Total %	100	100	100	100	100	100	100	100	100	100
<i>n</i>	263	66	263	43	174	34	183	17	620	276

Table 2. Availability and use of oak diameter classes in % (*dbh*: diameter at breast height). Signs and tests as in Table 1.

Oak's <i>dbh</i>	Ind.1		Ind.2		Ind.3		Ind.4		Unmarked	
	A	U	A	U	A	U	A	U	A	U
< 24 cm	14.0	3.3-	14.0	0.0-	0.0	0.0	13.3	0.0-	10.9	0.0-
24-36 cm	28.0	15.0-	28.0	17.0	28.6	6.3-	13.3	11.7	23.8	14.8-
36-52 cm	40.0	53.3	40.0	61.0+	52.3	43.7	33.4	41.2	40.6	49.3
52-72 cm	12.0	28.4+	12.0	22.0	19.0	43.8+	30.0	35.3	18.8	33.5+
≥ 72 cm	6.0	0.0-	6.0	0.0-	0.1	6.2	10.0	11.8	5.9	2.4-
Total %	100	100	100	100	100	100	100	100	100	100
<i>n</i>	50	60	50	41	21	32	30	17	101	209

crowns were used more often than the medium-sized (53% versus 47%). The comparison between availability and use of differently contacted oak crowns revealed significant differences (Friedman test, $T = 13.76$, $df = 4$, $P < 0.01$). The woodpeckers most often foraged in crowns being in contact with only one other crown; such preference occurred in two of five individuals (Table 3). Free standing oaks were used as expected, with the exception of the unmarked individuals which preferred these oaks. Crowns being in contact

with ≥ 3 other crowns were avoided. There was no correlation between number of contacts and oak diameter (Spearman rank correlation, $P > 0.2$ in all cases).

DISCUSSION

The Middle Spotted Woodpecker is restricted to mature deciduous forests (Winkler *et al.* 1995). These are characterized by high patchiness of dif-

Table 3. Availability and use of differently contacted oak crowns in %. Signs and tests as in Table 1.

No. contacts	Ind.1		Ind.2		Ind.3		Ind.4		Unmarked	
	A	U	A	U	A	U	A	U	A	U
0	2.4	12.7	2.4	13.5	0.1	17.9	0.0	0.0	1.1	9.9+
1	24.4	43.7+	24.4	40.5	23.7	28.6	14.8	31.3	21.3	44.0+
2	36.6	29.1	36.6	27.0	42.9	35.7	40.7	25.0	39.4	36.6
3	31.7	12.7-	31.7	16.3	19.0	17.8	22.2	37.4	25.8	7.9-
≥ 4	4.9	1.8	4.9	2.7	14.3	0.0-	22.3	6.3-	12.4	1.6-
Total %	100	100	100	100	100	100	100	100	100	100
<i>n</i>	41	55	41	37	21	28	27	16	89	191

ferent successional stages and a high amount of old trees and dead wood (Remmert 1991). Consequently, Lovaty (1980) found the highest breeding density in old forests (> 140 years), whereas young ones (< 40 years) lacked breeding pairs. Our study focuses on the characteristics of the foraging trees and covers the time before and during breeding. In addition, we worked with individually marked birds. Although there were only four of them, we did not register individuality in the foraging preferences, and pooling all data (with the unmarked birds) would not change the results in principle.

This woodpecker's dependence on oak (Jenni 1983, Pettersson 1983) is confirmed once more. Over 75% of these oaks had a diameter (*dbh*) of 36-72 cm, which corresponds to an age of > 120 years in this area. The selection of older oaks is explainable both with the foraging behaviour and with the high diversity of arthropods found on these trees (Nicolai 1986). The thick moss cover of old oaks is an important (wintering) refuge for arthropods (Grüebler 1997) and in addition with their rough bark structure, they offer a high supply of arthropods which renders the search and probe strategy advantageous. When foraging on other tree species, Middle Spotted Woodpeckers visited trees with rough bark texture like maple and Scots Pine more often than much more abundant species with smooth bark like Hornbeam. As woodpeckers often slide on smooth bark (pers. obs.), rough-barked trees probably facilitate loco-

motion due to the ladder-like function of the horizontal ridges (Jackson 1979), which could thus be an additional reason for preferring them.

Crown size was not a decisive factor for the foraging birds, whereas the number of contacts with adjacent crowns was crucial. The woodpeckers preferred to forage in crowns less contacted. Sunny crowns probably offer favourable conditions to arthropods, and their abundance should be higher than in shady crowns. However, woodpeckers might prefer crowns with less contacts simply due to their better accessibility.

The importance of dead and decaying wood as breeding substrate for woodpeckers is well-known. Many authors emphasize its positive influence on the Middle Spotted Woodpecker's density (e.g. Günther 1992). Furthermore, Schmitz (1993) argued that the forest disease or 'Waldsterben' might have a positive short-term effect as it promotes the supply of dead wood. However, its suitability as foraging substrate is ambiguous. In our study, the use of living and dead trees was in accordance to their availability and within trees, we observed foraging Middle Spotted Woodpeckers mostly on living substrates. There is some evidence that woodpecker species foraging on dead wood have to excavate their prey (Conner 1981, Raphael & White 1984), which requires pecking as foraging technique. However, we have shown that the Middle Spotted Woodpecker uses primarily searching and probing (see also Jenni 1983, Pettersson 1983). Hence, the birds are adapted to

exploit the superficial part of the bark, and consequently, arthropods in dead wood are hardly attainable. The amount of dead wood in the crown is positively correlated with the oak's *dbh* (own unpubl. data) and therefore, the suitability of crowns for foraging changes with oak diameter. Dead and decaying wood is undoubtedly required for the construction of the breeding cavity, but it is certainly not as important for foraging as for other woodpecker species (overview in Winkler *et al.* 1995).

The Middle Spotted Woodpecker is a very demanding species regarding the properties of its foraging habitat. Besides tree species, the requirements also include diameter (age), condition of substrate, and crown characteristics. In most of the intensively harvested forests in central Europe, suitable oaks are missing. However, timber harvesting does not necessarily mean destruction of habitat, but the extent and type of harvesting are crucial (Bühlmann & Pasinelli 1996). The needs of the Middle Spotted Woodpecker are best met in forests managed as coppice-with-standards ('Mittelwald'), which provide a high density of old oaks with sunny crowns. Therefore, habitat management for this endangered species implies long-term planning as it takes oaks more than 100 years to reach an adequate quality. The goals for the conservation of Middle Spotted Woodpecker are primarily maintenance of existing oakwoods and secondarily the promotion of oak in other forests to prevent isolation of this bird's populations.

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SAMENVATTING

Op veel plaatsen in zijn verspreidingsgebied neemt de Middelste Bonte Specht *Dendrocopos medius* sterk af in aantal. Uit grootschalige karteringen is bekend dat de soort eigenlijk alleen in eikenbossen voorkomt. Het

doel van deze studie was een beter begrip te krijgen van de specifieke eisen die de soort stelt aan deze eikenbossen. Het onderzoeksgebied bestond uit een hakhoutbos in het Zwitserse laagland. Het foerageergedrag van een viertal individueel gemerkte dieren en een groot aantal ongemerkte dieren werd intensief bestudeerd. Eiken *Quercus* spp. werden zeer sterk geprefereerd (Tabel 1), waarschijnlijk vanwege de ruwe schors en de grote aantallen insecten die zich daarin verschuilen. De soort spoort zijn prooien vooral op via zoeken en boren (Fig. 2). Boomsoorten met een gladde stam worden gemeden (Tabel 1), waarschijnlijk vanwege het geringe voedselaanbod en de moeite die deze soort heeft om niet van de gladde stam te glijden. De spechten zoeken vooral naar voedsel in de middelmatig grote kroon van levende eiken (Fig. 1). De geprefereerde eiken hadden op borsthoogte een stamdiameter van 36-72 cm, wat betekende dat ze minimaal 120 jaar oud waren (Tabel 2). Een ander opvallend kenmerk was dat ze niet helemaal los moesten staan, maar ook niet volledig omringd moesten zijn door andere bomen (Tabel 3). Op grond van deze bevindingen concluderen de auteurs dat deze soort alleen te beschermen is met een lange termijn beheer dat zorg draagt voor een beperkte kap, waardoor de aanwezigheid van oude eiken wordt gegarandeerd.

(BJE)

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