MASTERARBEIT

Titel der Masterarbeit

Nest Site Selection of Tawny Owls *Strix aluco* in Relation to Habitat Structure and Food Abundance in the Biosphere Reserve Wienerwald

Verfasserin

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Table of contents

I Figures

II Tables

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IV Zusammenfassung

Die vorliegende Masterarbeit befasst sich mit dem Einfluss von Habitatstruktur und Nahrungsverfügbarkeit auf die Nistplatzwahl des Waldkauzes *Strix aluco* im Biosphärenpark Wienerwald (westlich von Wien, Österreich). Zwischen März und Mai 2011 wurden 60 Nistkästen auf Brutversuche untersucht, im Mai in neun besetzten Nistkästen der Bruterfolg erfasst, und zwischen Juni und August im Umkreis der 60 Nistkästen und 30 (auf bewaldete Flächen beschränkten) Zufallspunkte 46 Habitatvariablen erhoben. Davon wurden 34 Variablen innerhalb eines Radius von 20 m (Mikrohabitat) erhoben und 12 innerhalb eines Radius von 250 m (Makrohabitat). Die Verfügbarkeit der Hauptbeutetiere wurde zwischen März und Mai durch Fangen in Lebendfallen (1.080 Falleneinheiten; Nagetiere) bzw. Kartieren entlang von sechs Strecken zu je acht Punkten (Vögel) erfasst. Statistische Analysen wurden mit dem Programm „R“ durchgeführt und beinhalteten Zweistichproben-t-Test, Wilcoxon-Mann-Whitney-Test, ANOVA, logistische Regression, PCA und LDA.

Obwohl der Waldkauz in seiner Habitatwahl sehr flexibel ist, konnten doch einige Besonderheiten festgestellt werden. Bei insgesamt sechs Habitatvariablen unterschieden sich besetzte und nicht besetzte Nistkästen signifikant. Die Waldkäuze schienen reine Hallenwälder weniger zu bevorzugen als etwas dichtere, strukturierte Waldabschnitte. Diese boten sowohl Deckung vor Mobbing durch Kleinvögel und Prädatoren, als auch Ansitzwarten für die Jagd. Im Vergleich zu Standorten mit mehr Nadelbäumen wurden 2011 in reinen Laubwäldern weniger Brutversuche unternommen. Möglicherweise ist die geringere Verfügbarkeit von Nagetieren im Jahr 2011, die in reinen Laubwäldern wahrscheinlich stärker ausgeprägt war, die Ursache dafür. Aufgrund der selektiven Montage von Nistkästen durch das Habichtskauz-Wiederansiedlungsprojekt-Team zeigten wie zu erwarten viele (18) Habitatvariablen signifikante Unterschiede zwischen Nistkästen und Zufallsflächen. Das Angebot an Kleinsäugern, der üblichen Hauptbeute des Waldkauzes, war außerordentlich gering. Insgesamt wurden nur 25 Nagetiere aus drei Arten (Rötelmaus *Chletrionomys glareolus*, Gelbhalsmaus *Apodemus flavicollis*, und Waldmaus *Apodemus sylvaticus*) gefangen. Die Anzahl an gefangenen Individuen betrug lediglich 0,02 pro 100 Falleneinheiten (33 g / Monat). Der Grund für die niedrigen Werte dürften die aufeinanderfolgenden fast ausgebliebenen Buchenmasten in den Jahren 2009 und 2010 gewesen sein. Besser war es um die Vogeldichte bestellt. Die Anzahl der Vögel lag bei ca. 500 Individuen pro Monat (dem entsprechen ca. 2.000 g Biomasse). In Summe wurden 1.568 Individuen aus mindestens 39 Arten erfasst. Die meisten Individuen und Arten wogen weniger als 19 g. Aus den Nahrungsanalysen war ersichtlich, dass die Waldkäuze als opportunistische Prädatoren das niedrige Angebot an Nagetieren ausglichen, indem sie auf Vögel als alternative Beute auswichen. Dass diese aufwändiger zu jagen sind ist möglicherweise die Ursache für die geringe Reproduktionsrate von 1,8 Jungen pro überprüftem erfolgreich brütenden Waldkauzpaar (n = 9 von 24). Die Nahrungszusammensetzung sah wie folgt aus: 20 Säugetiere (26,7 %), 45 Vögel (60,0 %), drei Reptilien (4,0 %), vier Amphibien (5,3 %), ein Fisch (1,3 %) und zwei Laufkäfer (2,7 %) (n = 75).

V Abstract

The thesis presented focuses on nest site selection of Tawny Owls *Strix aluco* in relation to habitat structure and food abundance in the Biosphere Reserve Wienerwald (to the west of Vienna, Austria). Breeding attempts in 60 nesting boxes were recorded from March to May 2011, breeding success in nine exemplary broods was controlled in May, and 46 habitat variables were measured at all of the 60 nest sites and at 30 random plots (located in forested areas only) from June to August. Of those 46 variables, 34 were recorded in the microhabitat with a radius of 20 m, and 12 were measured in the macrohabitat with a radius of 250 m. Abundance of main prey (rodents and birds) was recorded from March to May by trapping rodents with baited live traps (1,080 trapping units) and mapping birds at six locations with eight points each. Statistical analyses performed with the program “R” were Student’s t-test, Mann-Whitney-Wilcoxon-test, ANOVA, logistic regression, PCA and LDA.

Although Tawny Owls are flexible in habitat choice, some distinctive features could be noted. Significant differences between occupied and not occupied nest sites were found in six habitat variables. Tawny Owls seemed to prefer forests that were not completely hall-like, but more densely structured and thus provided cover from mobbing and predators, and could be used for hunting as well. Presumably due to the low rodent abundance in 2011, which probably was more pronounced in deciduous forests, fewer breeding attempts occurred in purely deciduous forests in comparison to nest sites with a higher number of coniferous trees. Between nest sites and random plots, 18 significant differences were found. These differences were expected because they were caused by the selective installation of nesting boxes by the Ural Owl reintroduction project team. Rodent abundance was extremely low in the study period. In three months, only 25 individuals of three species (Bank Vole *Chletrionomys glareolus*, Yellow-necked Mouse *Apodemus flavicollis*, and Wood Mouse *Apodemus sylvaticus*) were trapped. Only 0.02 individuals per 100 trapping units were recorded (33 g / month). This was most likely due to the almost complete failure of beeches to bear seeds in two consecutive years (2009 and 2010). In contrast, bird density was much higher. A total of 1,568 bird individuals belonging to at least 39 species were recorded, most of them weighed less than 19 g. Bird biomass ranged around 2,000 g each month (corresponding to ca. 500 individuals). Prey analysis showed that Tawny Owls as opportunistic predators compensated the low rodent abundance by switching to birds as alternative prey. Nevertheless, the reproductive rate was relatively low (1.8 nestlings per inspected successful breeding pair, n = 9 of 24). Prey composition was as follows: 20 mammals (26.7 %), 45 birds (60.0 %), three reptiles (4.0 %), four amphibians (5.3 %), one fish (1.3 %) and two beetles (2.7 %) (n = 75).

1 Introduction

Tawny Owls (*Strix aluco*, Linnaeus, 1758) are medium sized, stocky nocturnal predators with a wingspan of 81 – 96 cm. Body length ranges from 37 – 43 cm (SVENSSON 2011), and weight from 385 g – 800 g (DUNNING 1992). The species shows sexual dimorphism, with females being normally larger and heavier than males. They have dark eyes within a grey facial disc. Plumage colour is individual and varies between reddish brown and grey. They have light-coloured underparts with strong vertical and faint horizontal stripes (GLUTZ VON BLOTZHEIM ET AL. 1994).

The Tawny Owl is a common and widespread species in Europe. In northern, middle and southern Europe, it is represented by its subspecies *S. a. aluco* (AEBISCHER 2008), with 145,000 – 215,000 breeding pairs (BAUER & BERTHOLD 1996). In Austria, it is the most common owl (DVORAK ET AL. 1993) and numbers are assumed to have been stable since the 1970s, ranging between 3,000 – 3,500 breeding pairs (BAUER & BERTHOLD 1996). Here, the bird usually breeds between 200 – 600 metres above sea level (m. a. s. l.), but it may be found as high as 1,200 m. a. s. l., which corresponds to the upper limit for beech stands; broods at higher elevations are exceptions (DVORAK ET AL. 1993). In alpine regions, Tawny Owls avoid cold areas with continuous snow cover (GLUTZ VON BLOTHZEIM ET AL. 1994). In cultivated areas, the species is restricted to settlements (DVORAK ET AL. 1993). Owing to their low ecological specialization, Tawny Owls are missing only from treeless areas (MEBS & SCHERZINGER 2000). In optimal habitats, territory size may be as small as only seven to eight hectares (MEBS & SCHERZINGER 2000), but usually size ranges between 25 – 30 ha (GLUTZ VON BLOTHZEIM ET AL. 1994). In Austria, breeding densities are known only from two areas: in Vorarlberg, up to 2.5 pairs/ km^2 were found (SCHUSTER ET AL. 1983; KILZER & BLUM 1991), and in the Oberwart district, Burgenland, 1 pair/ km^2 was recorded (A. Gamauf in DVORAK ET AL. 1993). Tawny Owls prefer thin deciduous and mixed forests, but they are mainly depending on the availability of suitable places to breed, usually tree holes, but also niches in the rock or in buildings, as well as nests of other birds (crows, birds of prey), and also on the availability of sufficient roosting places and of course of prey (MEBS & SCHERZINGER 2000). Tawny Owls are opportunistic predators which use the most common prey type. Prey mostly consists of small mammals, but also birds, amphibians, insects and earthworms, and is hunted at night. The species is non-migratory and highly territorial (MEBS & SCHERZINGER 2000), pairs are monogamous and stay together for their whole life (SCHERZINGER 1980). They breed only once a year: three to five eggs are laid in March and incubated for 28 – 30 days. The nestling period lasts 29 – 35 days, and the young need another three months until independence (GLUTZ VON BLOTHZEIM ET AL. 1994). Apart from the information given above, little detailed knowledge is available about the Tawny Owl because of its nocturnal lifestyle.

This master thesis focuses on the Tawny Owl in the Biosphere Reserve Wienerwald ("Biosphärenpark Wienerwald", BPWW). It is a wooded region to the west of the capital Vienna. In the year 2009, the extensive installation of nesting boxes in the BPWW began to support the reintroduction project of the Ural Owl (*Strix uralensis*) in Austria (ZINK & PROBST 2009). For the time being, many Tawny Owls occupied these nesting boxes and created a favourable opportunity to investigate this elusive species. In these nesting boxes, they can easily be found and accessed for investigations.

The aims of this study were 1) to investigate nest site selection of Tawny Owls at the micro- and macrohabitat level in a well forested region, and 2) to compare the nest sites with randomly selected plots, and 3) to examine the abundance of the two main prey categories, rodents and birds, in relation to prey choice.

2 Material and methods

2.1 Study area

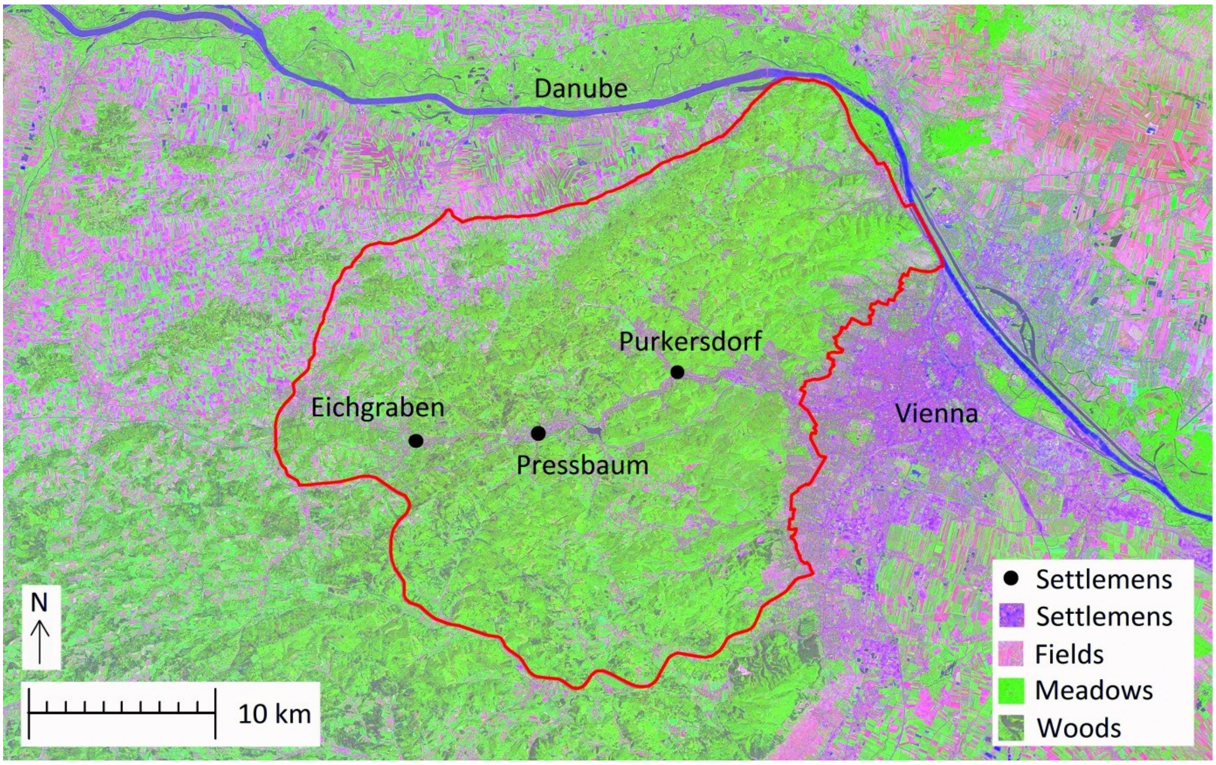

Figure 1: Location of the study area in the Austrian federal states Vienna and Lower Austria. Boundaries of the study area are drawn in red. Main villages of the region are marked. Scale: 1:150,000. © NASA Zulu.

The study area is situated in the Vienna Woods to the west of Austria's capital Vienna. The Vienna Woods cover an area of 135,000 hectares, about 52 % (70,000 ha) of it are forested (SAUBERER ET AL. 2007). The dominating forest types are beech forest and, especially at low levels, oak hornbeam forest, but altogether the woods consist of more than 20 forest types (LAMMERHUBER ET AL. 2010; ANONYMOUS 2011a). The forest is composed of different tree species: European Beech *Fagus sylvatica* (54.7 %), European Hornbeam *Carpinus betulus* (5.7 %), Oak *Quercus* spp. (5.5 %), European Ash *Fraxinus excelsior* and other deciduous species (2.2 % each); the most common coniferous species is the Norway Spruce *Picea abies* (11.2 %), followed by European Silver Fir *Abies alba* (2.1 %), European Larch *Larix decidua* (5.8 %), Pines *Pinus* spp. (10.1 %), and other coniferous species (0.4 %) (SAUBERER ET AL. 2007). The second most common habitat type is meadows (LAMMERHUBER ET AL. 2010). Upper courses of many streams and rivers are still preserved in their natural state and accommodate for example the stone crayfish (*Austropotamobius torrentium*, Schrank, 1803), which is sometimes preyed on by the Tawny Owl (ANONYMOUS 2011b).

Due to climate and soil reasons, arable land is scarce, and there are only few villages. Elevation ranges between 160 and 893 m above sea level (LAMMERHUBER ET AL. 2010). The northern and western parts of the Vienna Woods lie in the Flysch zone (composed mainly of marl and slate with deposits of sandstone), the southern part in the Cliff zone (composed of limestone and magnesian limestone) (SAUBERER ET AL. 2007). The climate of the Vienna Woods is sub-continental, meaning there are cold winters and warm, dry summers. The average temperature of the hottest month is 20° C, of the coldest month -0.3° C (LAMMERHUBER ET AL. 2010). The annual mean temperature is approximately 9.2° C (ANONYMOUS 2011g). Precipitation amounts to up to 900 mm per year (DVORAK ET AL. 1993).

2.1.1 Biosphere Reserve Wienerwald ("Biosphärenpark Wienerwald")

In 2005, the Vienna Woods were declared a biosphere reserve by the UNESCO. The BPWW includes 51 municipalities of Lower Austria and seven districts of Vienna. It covers an area of 105,645 hectares, 63 % of which are covered by forest (67,000 ha) (SAUBERER ET AL. 2007; LAMMERHUBER ET AL. 2010).

As a biosphere reserve, the area is characterised by its extraordinary natural and artificial landscapes. Important objectives of biosphere reserves are the protection of ecosystems and landscapes as well as of biological and genetic resources, and at the same time the preservation of diverse cultural values. With this in mind, they strive for the development and promotion of sustainable forms of ecological, economic and sociocultural land use. They want to achieve a better understanding of the interactions between humans and nature by supporting education, environmental monitoring and research (ANONYMOUS 2011c; ANONYMOUS 2011d).

In order to simplify the achievement of the goals mentioned above, the landscapes of biosphere reserves are classified under 3 different zones: core areas, buffer zones and transition areas. In the BPWW, transition areas amount to 76 % of the total area and contain 52,300 ha managed forest. They provide room for the local economy and are at hand for recreational purposes to improve the quality of life of the population. Buffer zones contribute 19 % of the area of the BPWW and contain artificial landscapes created by humans that should be tended and preserved. Another function of buffer zones is to protect core areas from disturbances and damage. Only 5 % (about 5,000 ha) of the BPWW are composed of core areas. These 37 areas are distributed all over the biosphere reserve and exclusively cover wooded areas. Owners of areas declared as core area do not economically utilize these areas, so dying and dead trees remain in the forest and nature can develop unimpaired by human activities. UNESCO demands that core areas be protected legally. Possible means of protection are for example nature habitats and landscape conservation areas. In nature reserve areas, human interference is forbidden in order to protect unspoilt habitats for rare species. Landscape conservation areas are meant to preserve typical landscapes for recreational purposes (SAUBERER ET AL. 2007; ANONYMOUS 2011c; ANONYMOUS 2011e; ANONYMOUS 2011f).

Vienna and Lower Austria have adopted different strategies. In Vienna, all core areas and a large part of the whole Viennese BPWW are protected as landscape conservation areas. Only some core areas are additionally protected as nature habitats. The whole Lower Austrian part of the BPWW is protected as landscape conservation area, and all core areas are protected as nature habitats. Additionally, parts of the Lower Austrian as well as the Viennese part of the BPWW have been declared Europe reserve areas (protected by regulations of the NATURA 2000 programme) (ANONYMOUS 2011c).

Apparent from Figure 1, not the whole BPWW was adopted as study area. The Wiener Außenring Autobahn A21 represented the southern boundary of the study area chosen. The size of the study area therefore amounted to only 67,121 ha.

2.2 Artificial nesting boxes

Sixty nesting boxes were installed in the BPWW between January 2009 and March 2011. They are modified rubbish bins made of hard plastic (width x depth x height: 40 x 40 x 60 cm) filled with fine woody debris (soft woody debris crumbled by hand) taken from the surrounding forest. A rectangular entrance hole is cut into the front (30 x 30 cm). Several holes drilled in the floor provide an outlet for water. Each box is attached to its tree by several metal bars with screws and nails. An example of a nesting box is shown in Figure 3. The coordinates of the boxes were saved on a GPS navigation device upon installation. Figure 2 shows the location of the nesting boxes.

All boxes were checked for breeding attempts (eggs or young) between March and early May 2011. Empty nesting boxes were revisited approximately every two weeks until they were occupied or until early May at the longest. The boxes were found with a GPS navigation device (Garmin GPSmap 62s) on which the coordinates of the boxes were saved at installation. To avoid disturbances of breeding owls, each nesting box was equipped with a small mirror above the entrance hole so that the contents of the box could be seen from the ground with binoculars (Swarowski EL 10x42). A breeding attempt was defined as an owl being present in a nesting box. Breeding success or failure was not recorded for all occupied nests. For some nesting boxes, the number of eggs or young was collected in the course of other field work.

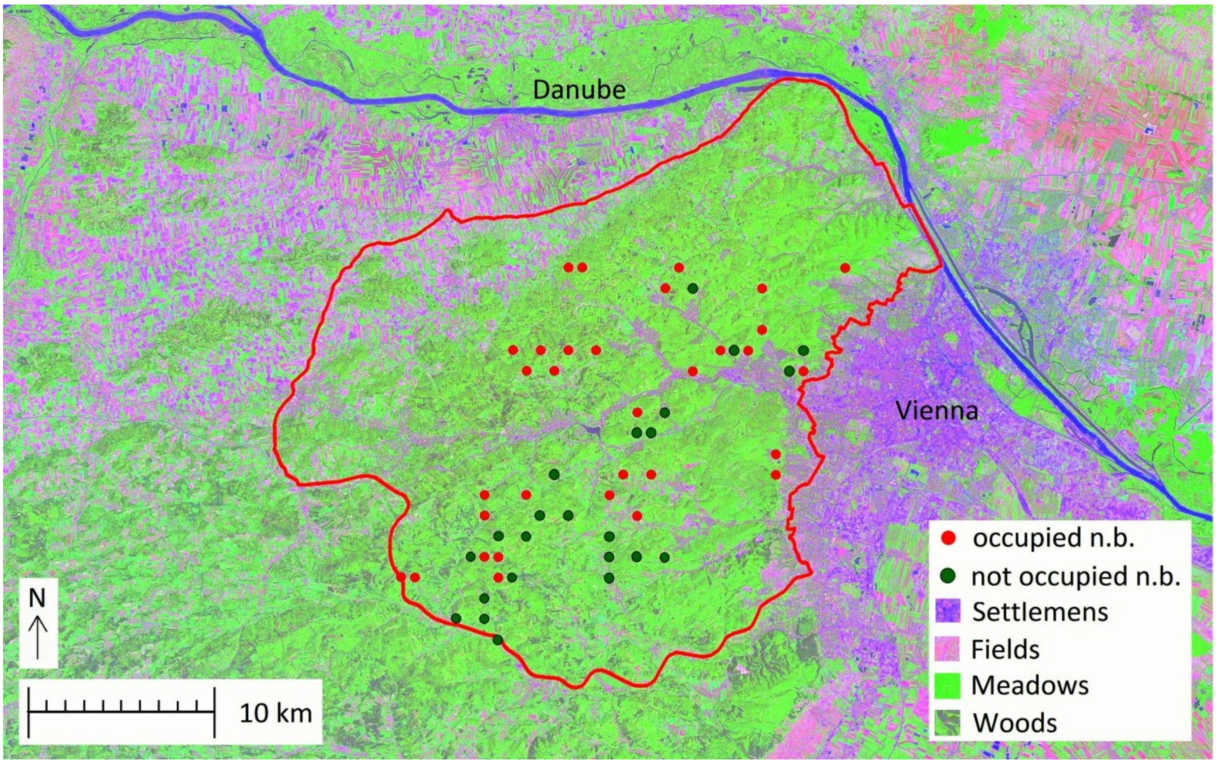

Figure 2: Location of nesting boxes within study area. n. b. = nesting boxes; red line = boundaries of study area; red dots = nesting boxes occupied by Tawny Owls (n = 24); green dots = nesting boxes not occupied by Tawny Owls (n = 36). Some dots overlap because coordinates of nesting boxes were entered to only 2 decimal places. Scale: 1:150,000. © NASA Zulu.

Figure 3: Nesting box used in this study attached to a beech tree. Scene shown in the photograph: climber approaching nesting box from the ground for investigation of young Tawny Owls in May. © 2011 Julia Gstir.

2.2.1 Condition of young

Although breeding success was not investigated in this study, some nesting boxes were visited in May 2011 to gain some basic data on the general condition of the young Tawny Owls. Of the 24 breeding attempts registered in the study area, the breeding success of a sample of 9 successful broods was inspected. The number of young (and/or eggs), as well as colour morph, weight, tarsus length, wing length (from bend of the wing to the tip of the longest primary feather), tail length (length of central tail feathers from outlet to tip; as well as length of vane from blood quill to tip), parasitic infestation (number of ectoparasites detected) and nutritional condition (shape of pectoral muscle, grades 0-3) were recorded. Weight was measured with a digital scale (Soehnle 8027 ultra) to the nearest 0.1 g (Figure 4); length of tarsus and tail were measured with a vernier calliper (Digitaler Meßschieber Digimax®-Fieberglas) to the nearest mm; and length of wing was measured with a metal ruler to the nearest 0.1 cm (DEUTSCHE ORNITHOLOGEN-GESELLSCHAFT 2011). Age of young was afterwards determined on the basis of tail length and weight according to MELDE (1989). Deduced from the age of the young at the time of the inspection, date and length of incubation (29 days) and nestling period (32 days) were determined (GLUTZ VON BLOTZHEIM ET AL. 1994).

In the course of nest inspection, pellets and prey remains were collected to examine the actual food composition of the owls.

Figure 4: Weighing of a Tawny Owl nestling during control of nine nesting boxes in the Biosphere Reserve Wienerwald in May 2011.

2.3 Habitat

2.3.1 Nest sites

The term "nest site" in this study exclusively refers to sites at which a nesting box under investigation (n = 60) is installed. An example of a nest site (microhabitat) is shown in Figure 5. Habitat data was collected at nest sites from June to August 2011 at three levels: 1) the nest tree and nesting box, 2) the microhabitat (radius of 20 m around the nest tree), and 3) the macrohabitat (radius of 250 m around the nest tree). A detailed list of the variables recorded at each of these levels, as well as their detailed descriptions is given in Table 1. The variable Heightbox was measured at the side of the tree where the nesting box was fixed. To preserve uniformity, only water bodies included in the ÖK50 were recorded in the variable Water, smaller water bodies possibly discovered at a survey point were disregarded. Those variables indicating distances (Edge, Water, Settlement, Pavroad, Unpavroad, Box, Boxoc, Rbio, and Bbio) were also measured if the distance exceeded the 250 m radius of the macrohabitat. For biomass of rodents and small birds, data from March was used because breeding habitat selection takes place around that time.

Figure 5: Beech forest at a nest site (NB 13, not occupied) in the study area in May 2011.

Table 1: List and definition of all habitat variables recorded at occupied and not occupied Tawny Owl nesting habitats and random points, and their units and abbreviations. [m] = metres; [m. a. s. l.] = metres above sea level; [°] = degrees; [g] = grams.

Nr.	Variable	Abbreviation	Definition
Nest tree and nesting box			
1	ID of nesting box	NB	ID of nesting box (4-133, some numbers were skipped)
2	Occupation of nesting box	Occupation	Nesting boxes in which a brood was attempted in 2011 were categorized as “occupied”; nesting boxes without a breeding attempt were categorized as “not occupied”
3	Height of nesting box [m]	Heightbox	Distance between floor of the nesting box and base of the nest tree
4	Exposition of entrance hole [°]	Exposition	Direction in which the entrance hole of the nesting box faces (0-360°)
5	Position of nest tree	Position	Position of the nest tree on the slope: hilltop (1), uphill (2), downhill (3), foot of the slope (4)
6	Altitude of nest tree [m. a. s. l.]	Altitude	Altitude of the base of the nest tree above mean sea level

Table 1 – CONTINUED: List and definition of all habitat variables recorded at occupied and not occupied Tawny Owl nesting habitats and random points, and their units and abbreviations. [m] = metres; [m. a. s. l.] = metres above sea level; [°] = degrees; [g] = grams.

Nr.	Variable	Abbreviation	Definition
7	Nest tree species	Species	European Beech *Fagus sylvatica* (1), Oak *Quercus* spp. (2), Maple *Acer* spp. (3)
8	Diameter of nest tree [cm]	Dbh	Diameter of nest tree at breast height (d.b.h.)
9	Height of nest tree [m]	Heighttree	Height of nest tree from base to treetop
10	Canopy closure [%]	Canopy	Amount of contact between crown of nest tree and crown of its immediate neighbour trees (0% = no contact, 100 % = contact along the whole circumference of the crown of the nest tree)
Microhabitat (within 20 m radius)			
11	Slope [°]	Slope	Slope at the base of the nest tree
12	Ground cover [%]	Groundcover	Amount of ground covered by live vegetation shorter than 1 m
13	Number of shrubs	Nrshrubs	Number of shrubs higher than 1 m
14	Height of shrubs [m]	Heightshrubs	Mean height of all shrubs higher than 1 m
15	Number of understory trees	Nrust	Number of all trees higher than 1 m but not contributing to canopy layer
16	Nr. of understory trees <5 cm	Nrust5l	Number of understory trees with d.b.h. less than 5 cm
17	Nr. of understory trees >5 cm	Nrust5m	Number of understory trees with d.b.h. more than 5 cm
18	Height of understory trees [m]	Heightust	Mean height of all understory trees
19	Number of overstory trees	Nrost	Number of trees contributing to canopy layer
20	Nr. of overstory trees <25 cm	Nrost25	Nr. of overstory trees with d.b.h. less than 25 cm
21	Nr. of overstory trees 25-40 cm	Nrost2540	Nr. of overstory trees with d.b.h. from 25 to 40 cm
22	Nr. of overstory trees >40 cm	Nrost40	Nr. of overstory trees with d.b.h. more than 40 cm
23	Nr. of European Beech *Fagus sylvatica*	Fag	Nr. of European Beech contributing to canopy layer
24	Nr. of Oak *Quercus* spp.	Que	Nr. of Oaks contributing to canopy layer
25	Nr. of other deciduous trees	Dec	Nr. of other deciduous trees (not beech or oak) contributing to canopy layer
26	Nr. of Norway Spruce *Picea abies*	Pic	Nr. of Norway Spruce contributing to canopy layer

Table 1 – CONTINUED: List and definition of all habitat variables recorded at occupied and not occupied Tawny Owl nesting habitats and random points, and their units and abbreviations. [m] = metres; [m. a. s. l.] = metres above sea level; [°] = degrees; [g] = grams.

Nr.	Variable	Abbreviation	Definition
27	Nr. of other coniferous trees	Conif	Nr. of other coniferous trees (not Norway Spruce) contributing to canopy layer
28	Number of dead trees	Nrdead	Nr. of dead understory and overstory trees standing (upright or tilted) or lying
29	Nr. of dead trees <25 cm standing	Nrdead25st	Nr. of standing dead trees with d.b.h. less than 25 cm
30	Nr. of dead trees <25 cm lying	Nrdead25l	Nr. of lying dead trees with d.b.h. less than 25 cm
31	Nr. of dead trees 25-40 cm standing	Nrdead2540st	Nr. of standing dead trees with d.b.h. from 25 to 40 cm
32	Nr. of dead trees 25-40 cm lying	Nrdead2540l	Nr. of lying dead trees with d.b.h. from 25 to 40 cm
33	Nr. of dead trees >40 cm standing	Nrdead40st	Nr. of standing dead trees with d.b.h. more than 40 cm
34	Nr. of dead trees >40 cm lying	Nrdead40l	Nr. of lying dead trees with d.b.h. more than 40 cm
Macrohabitat (within 250 m radius)			
35	Forest cover [%]	Forest	Percentage covered by forest (green colouration in the ÖK50)
36	Distance to nearest forest edge [m]	Edge	Forest edge is defined as the boundary of an area coloured in green in the ÖK50
37	Distance to nearest water body [m]	Water	Water body is defined as any water body (flowing or standing) registered in the ÖK50
38	Distance to nearest human settlement [m]	Settlement	Distance to the nearest building of a settlement, defined as a group of 3 buildings or more
39	Distance to nearest paved road [m]	Pavroad	Paved roads are defined as motorways or first/second/third order roads in the ÖK50
40	Distance to nearest unpaved road [m]	Unpavroad	Unpaved roads are defined as roadways or wide footpaths in the ÖK50
41	Length of paved road [m]	Pavroadl	Added lengths of all paved pieces of roads within the 250 m radius
42	Length of unpaved road [m]	Unpavroadl	Added lengths of all unpaved pieces of roads within the 250 m radius
43	Distance to nearest nesting box [m]	Box	Distance to the nearest nesting box (occupied or not occupied; same as variable nr. 44 if nearest nesting box is occupied)
44	Distance to nearest occupied nesting box [m]	Boxoc	Distance to nearest occupied nesting box

Table 1 – CONTINUED: List and definition of all habitat variables recorded at occupied and not occupied Tawny Owl nesting habitats and random points, and their units and abbreviations. [m] = metres; [m. a. s. l.] = metres above sea level; [°] = degrees; [g] = grams.

Nr.	Variable	Abbreviation	Definition
45	Biomass of rodents in March [g]	Rbio	Biomass of all rodents caught in March on the trapping site nearest to the nesting box
46	Biomass of birds in March [g]	Bbio	Biomass of all birds registered in March on the transect nearest to the nesting box

The following tools were used for collecting habitat data: a hypsometer (Suunto PM-5/1520) was used for measuring the variables Heightbox and Heighttree, and Slope; a compass (TCM) for Exposition; a GPS navigation device (Garmin GPSmap 62s) for Altitude; and a tape measure (Prym) for Dbh. Canopy closure, ground cover, and height of shrubs and understory trees were assessed visually. Maps (BEV ÖK50 Wien-Umgebung, Google earth 5.2.1.1588) were used for forest cover (visually assessed in the ÖK50), distance to forest edge, water body, settlement, paved road and unpaved road, length of paved road and unpaved road (measured in the ÖK50 with a ruler), and distance to nearest nesting box and nearest occupied nesting box (digital measurement in Google earth 5.2.1.1588). The diameters of trees were calculated individually afterwards from the girths of the trees.

2.3.2 Random plots

Thirty random plots where established to compare random forest structure with that found at nest sites. Selection of random plots was achieved by drawing a polygon representing the study area in Google earth and clicking blindly onto the screen with the mouse. A click within a forest patch was accepted as a random plot. A click outside a wood or outside the polygon was rejected. The accepted random plots were then transferred to a GPS. Their locations are shown in Figure 6. Upon arrival at a random plot, a piece of wood was thrown blindly and the overstory tree hit was chosen as centre of random habitat. If the piece of wood did not hit an overstory tree, it was thrown again.

The same habitat variables as in nesting habitats were recorded in random habitats from June to August 2011. However, some small adaptations had to be made. There was no “nest tree” with a nesting box attached to it available at a random plot. The tree at the centre of a random habitat was referred to as “random tree” instead. Since there was no nesting box, the variables Occupation, Heightbox and Exposition were omitted. Whereas nest trees were either European Beech, Oak or Maple, random trees included nine different species. A summary of the alterations can be seen in Table 2.

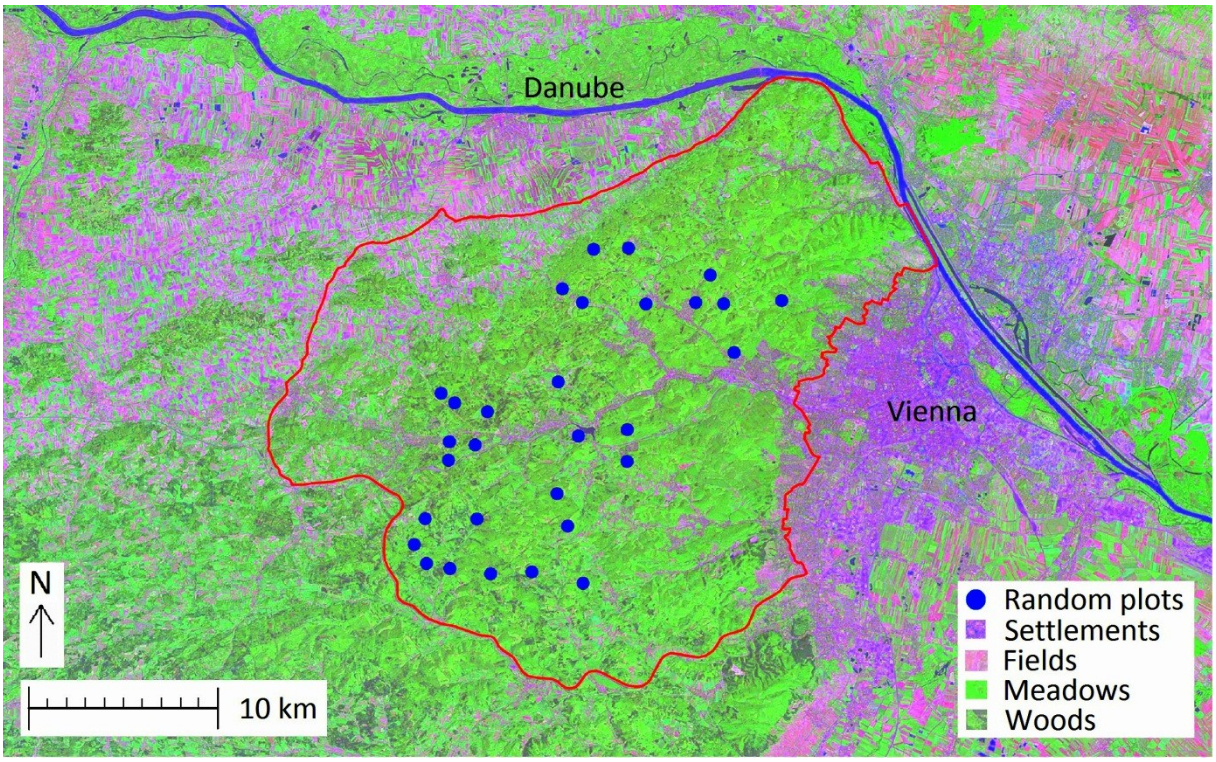

Figure 6: Location of random plots within study area. Red line = boundaries of study area; blue dots = random plots (n = 30). Scale: 1:150,000. © NASA Zulu.

Table 2: List of alterations made in recording habitat variables at random plots in contrast to Tawny Owl nesting habitats, and the units and abbreviations of these habitat variables. [m] = metres; [°] = degrees; [g] = grams.

Nr.	Variable	Abbreviation	Definition
1	ID of random tree	RP	ID of random tree (901-930)
2	*Occupation of nesting box*		*Not applicable*
3	*Height of nesting box [m]*		*Not applicable*
4	*Exposition of entrance hole [°]*		*Not applicable*
7	Random tree species	Species	European Beech *Fagus sylvatica* (1), Oak *Quercus* spp. (2), European Hornbeam *Carpinus betulus* (4), Norway Spruce *Picea abies* (5), European Ash *Fraxinus excelsior* (6), Douglas-Fir *Pseudotsuga menziesii* (7), Wild Cherry *Prunus avium* (8), European Larch *Larix decidua* (9), Elm *Ulmus* spp. (10)

2.4 Prey abundance

The diet of Tawny Owls consists mainly of small mammals, but birds and amphibians may contribute a considerable part too. Occasionally, fish, reptiles, crustaceans, molluscs, insects (especially beetles) and earthworms can be found in the diet (GLUTZ VON BLOTZHEIM ET AL. 1994). In this study, I gathered information on the frequency of rodents and small birds in the Vienna Woods in spring 2011 by trapping rodents and mapping birds. Information on the consumption of different types of prey by the Tawny Owl was gathered through analysis of pellets and prey remains.

2.4.1 Rodents

Within the study area, six locations were chosen for trapping rodents from March to May 2011. The locations represented different types of forest typical of the Vienna Woods providing potential suitable habitat for rodents: European Beech without undergrowth, European Beech with little undergrowth, European Beech with thick undergrowth, Oak, mixed forest (European Beech, Oak, Norway Spruce), and Norway Spruce. All six locations are shown in Figure 7.

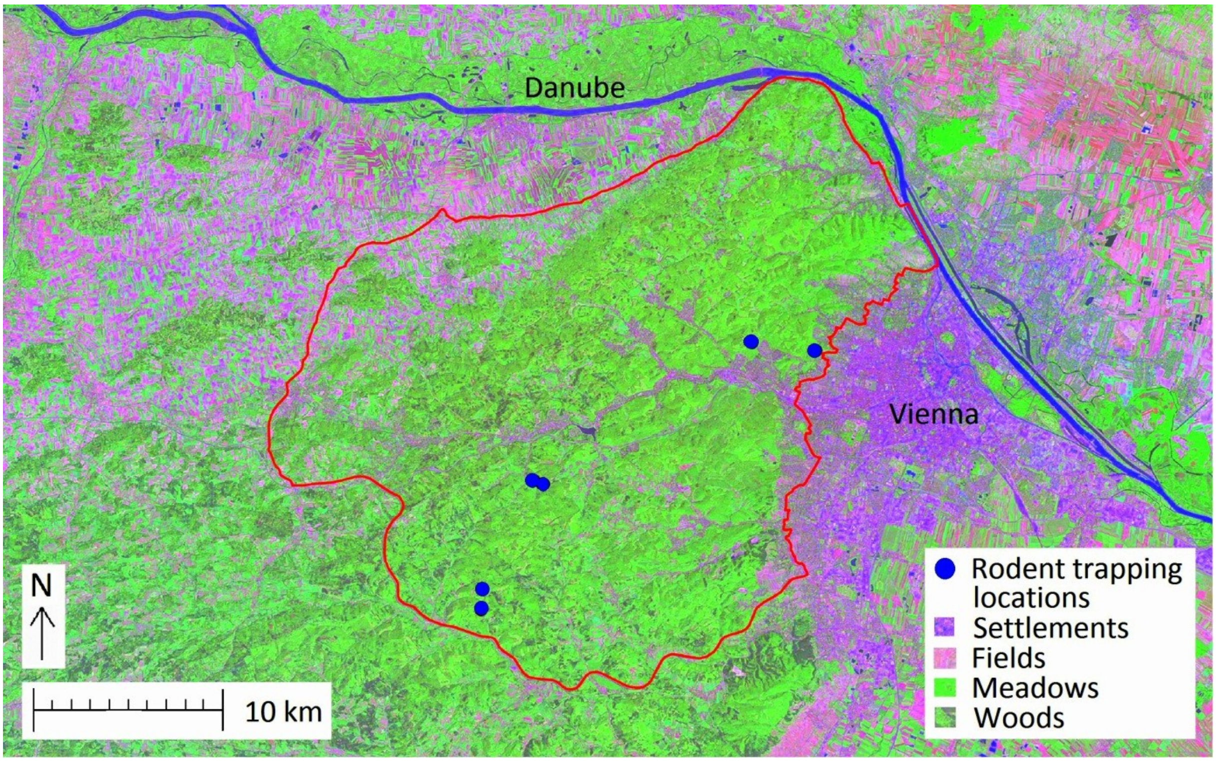

Figure 7: Rodent trapping locations within study area. Red line = boundaries of study area; blue dots = rodent trapping locations (n = 6). Scale 1:150,000. © NASA Zulu.

Each of the locations was visited for a trapping session of two consecutive days in March, April and May. In the morning of the first day, 20 metal live traps of the Rögel type were placed in two rows (2 x 10 traps), with a distance of 10 m between each trap and its nearest neighbour. The traps were placed alongside structures used by rodents for cover (e.g. tree trunks, logs, or fallen branches). They were filled with peanut butter and several mealworms as bait. A food rich in energy such as peanut butter was needed because there was always the possibility that a rodent would enter a trap several hours before the next inspection, and nights were still cold. Mealworms providing even more energy were added in case a shrew (*Soricidae*) would be caught in a trap. The first inspection was carried out in the evening of the same day. During an inspection, trapped rodents were measured, determined, marked and then set free again. Bait was renewed in traps where it had been diminished, and faeces were removed. In the rare event that a trap had closed by accident, it was opened again. A second inspection was conducted in the morning of the following day. On the third and last visit in the evening of the second day, the traps were not only inspected, but also removed. All traps were emptied of bait and cleaned after each trapping session. In case of rainy weather, planned trapping sessions were postponed until the weather was suitable. No trapping sessions had to be interrupted or stopped because of rain. Three inspections in each of the three months at six locations with 20 traps each resulted in a total of 1,080 trapping units.

Parameters determined for each rodent were species, weight, body length, tail length, length of hind foot, and ear length. Species determination was based on JENRICH ET AL. (2010a). Study skins from the mammal collection of the Museum of Natural History in Vienna were inspected prior to field work. Weight was measured with a digital scale (Soehnle 8027 ultra) to the nearest 0.1 g (Figure 8). Body length (from tip of nose to beginning of hairless base of tail), tail length (from hairless base to tip of tail), hind foot length (from heel to the tip of the middle toe, excluding claw), and ear length (from base of outer ear, i.e. indentation of the cartilage, to outmost tip of outer ear) were measured with a ruler to the nearest mm (JENRICH ET AL. 2010a). To be able to recognize recaptured rodents, each individual was marked by cutting a patch of hair at its back before setting it free.

Figure 8: Weighing of a rodent in the course of determining body parameters in the Biosphere Reserve Wienerwald in March 2011.

2.4.2 Birds

Mapping of small birds (representing potential prey species of Tawny Owls) was carried out along six transects within the study area from March to May 2011. Their locations were chosen in a way to provide a good representation of the composition of forest types. Each transect consisted of eight observation points, with a distance of 250 m between the points. All but one transects were placed along forest roads classified as “roadways” in the ÖK50. One transect ran along a path beside a wire-netting fence. The locations of all six transects are shown in Figure 9.

Mapping followed the Brutvogelmonitoring directions by Birdlife Austria (DVORAK & TEUFELBAUER 2008). Each transect was visited for mapping once each in March, April and May. Counts started early in the morning and were to be finished before 10 a.m. Upon arrival at a point, two minutes of silence were held to allow the birds to calm down and the observer to gain a surface impression of the species composition in the surroundings. All birds discovered visually and/or acoustically within the subsequent five minutes were recorded. Binoculars (Swaroski EL 10x42) were used to aid discovery of birds and visibility of characteristics needed for species identification. Recognition of bird calls and songs was practised with the help of the CDs "Die Vogelstimmen Europas" (ROCHE 2000). In case of windy or rainy weather, planned mappings were postponed until the weather was suitable. In March, two mappings had to be postponed because of wind or rain.

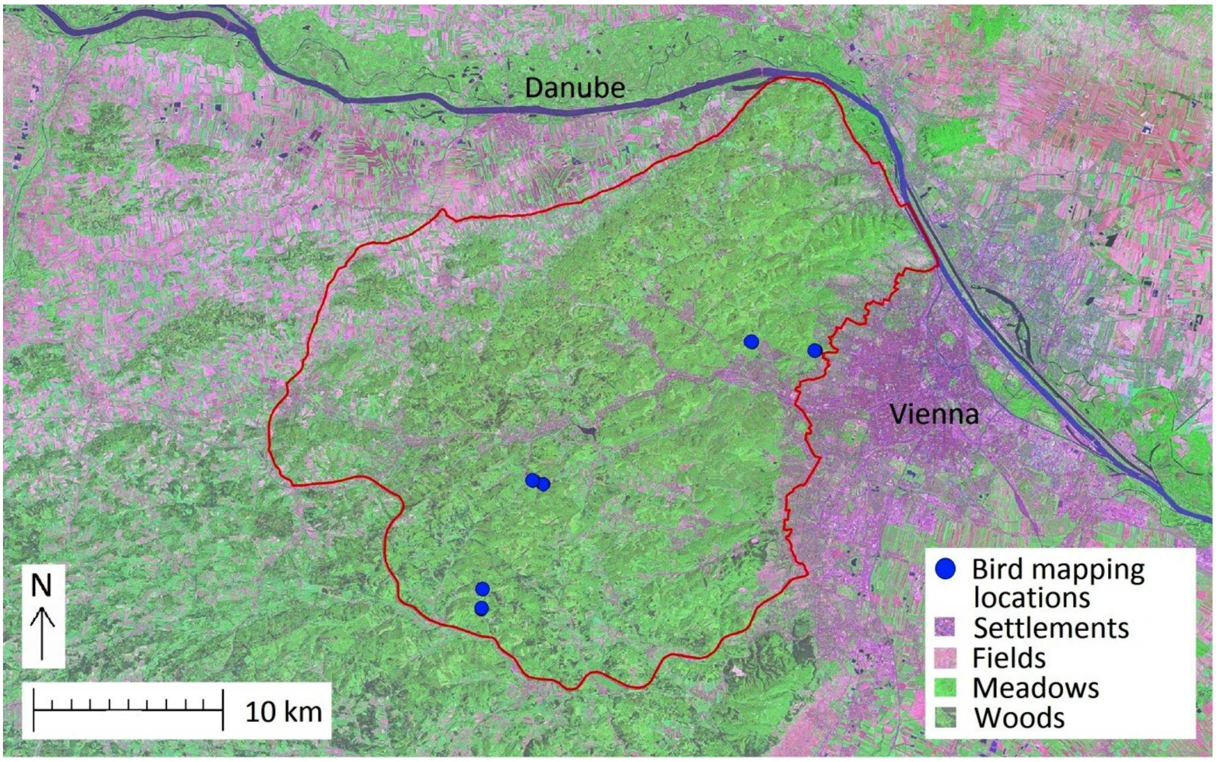

Figure 9: Bird mapping locations within study area. Red line = boundaries of study area; blue dots = bird mapping locations (n = 6). Scale: 1:150,000. © NASA Zulu.

Besides species identification, type of behaviour (sighting, sighting in flight, call, song), and sex (if discernible) were recorded. Individuals that were sighted in company of each other were listed together in brackets. Individuals whose species could not be discerned were listed as "unspecified". The category "unspecified" was either dealt with as an independent category, or included in the lightest weight category, or excluded from analyses (e.g. analyses regarding biomass or the number of species). Average weight of each species needed for further analyses was extracted from GLUTZ VON BLOTZHEIM ET AL. (1994). The category "unspecified" was included in the lightest weight category because all unspecified individuals had a figure or voice strongly suggesting that they belonged to a small species. Species with an average weight exceeding 300 g were excluded from analyses because Tawny Owls only sporadically prey on birds of this size (SMEENK 1972; KÄLLANDER 1977; GALEOTTI ET AL. 1991; GLUTZ VON BLOTZHEIM ET AL. 1994; MEBS & SCHERZINGER 2000).

2.4.3 Prey remains

Nest controls were conducted between 17 and 19 May 2011. Pellets and prey remains from nine nesting boxes were collected and stored in individual sealed bags. They were dried before analyses. After identification, certain body parts were counted to estimate minimum individual prey numbers. Feathers were identified by comparing them with feather collections and study skins from the bird collection at the Museum of Natural History in Vienna. Bones were identified using the skeleton collection of the bird and mammal collection at the same museum as reference material. Additionally, identification literature was used (UTTENDÖRFER 1939; GLUTZ VON BLOTZHEIM ET AL. 1994; JENRICH ET AL. 2010b).

To estimate the dietary diversity (breadth) of Tawny Owls, the standardised food niche breadth (SFNB: COLWELL & FUTUYMA 1971) was calculated. Dietary diversity has two components: 1) richness (number of prey species), and 2) evenness (how uniform the different prey species are). Prey diversity is high (equivalent to a broader food niche) if many prey species are included in more or less equal numbers. Diversity is low (equivalent to a narrower food niche) if prey consists of few species in different abundances. SFNB is calculated using the following formula:

$$SFNB = \frac{B_{obs} - B_{min}}{B_{max} - B_{min}}$$

B_{obs} = 1 / total pi^2 (pi is the proportion of each prey species)

B_{max} = total number of prey species

B_{min} = minimum number of prey species

2.5 Statistics

All statistical analyses were performed using "R" (version 2.13.2 2011-09-30). Commands were entered via R-Studio (version 0.94.110 2009). Further processing of results was performed in Microsoft Office Excel 2010. Significance level for all analyses without exception was defined as α = 0.05.

2.5.1 Descriptive analyses

As a first step, some descriptive analyses were made to gain an overview of the data. Mean, standard deviation (SD), minimum and maximum, as well as mean absolute deviation (MAD) were calculated for each category (occupied nest sites, not occupied nest sites and random plots) of each habitat variable separately (nominal variables excepted). For the nominal habitat variables (Occupation, Position, Species), only frequency analyses are possible, so they were plotted in histograms. For better visualization, boxplots were made. These compared occupied and not occupied nest sites and random plots with each other, others compared nest sites in general with random plots, and yet others visualized the development of prey abundance from March to May.

In a second step, preconditions for further analyses were tested. All habitat variables were tested for normal distribution and homogeneity of variance. Normally distributed variables (Altitude, Dbh, Heighttree, Slope, Nrost, Nrost2540, Nrost40, Fag, Pavroad and Unpavroadl) were then subject to Student's t-tests; Mann-Whitney-Wilcoxon-tests were performed on not normally distributed variables. Student's t-tests were adjusted according to homogeneity of variance of tested variables. Some variables were excluded from some tests if no data was collected at random plots, so no comparison was possible (variables Exposition, Dbh, Rbio, and Bbio); or if all values of a variable equalled 0 (variable Nrdead40st).

2.5.2 Further analyses

Further analyses included Student's t-tests, Mann-Whitney-Wilcoxon-tests, analyses of variance (ANOVAs), logistic regressions (general linear models), principal component analyses (PCAs) and linear discriminant analyses (LDAs) of habitat variables. Logistic regression, PCA and LDA were chosen because they are standard methods to discriminate between groups.

Student's t-tests and Mann-Whitney-Wilcoxon-tests were conducted to show which habitat variables exert the strongest influence on whether a nesting box was occupied or not. The variables Heightbox and Exposition had to be excluded from the comparisons between random plots and occupied or not occupied nest sites because these variables do not occur at random plots; the variables Position and Species were also excluded because they are nominal.

For the two nominal variables Position and Species, an ANOVA was performed in addition to plotting histograms.

Several logistic models were calculated to check for linear relationships between Occupation and the other habitat variables. As the dependant variable (Occupation) only has two or three expressions respectively, I resorted to logistic regression. Initially, each habitat variable (except those variables not recorded at random plots) was transformed and then tested separately for its linear relationship with the variable Occupation (occupied vs. not occupied nest sites, as well as both put together as "nest sites" opposed to random plots). Following this, an overall logistic regression for all variables showing significant results in the separate analysis was carried out, one for occupied vs. not occupied nest sites, and one for nest sites vs. random plots. In the assembled analysis comparing nest sites and random plots an overdispersion occurred, so I calculated two separate models, each with as many variables as possible (1st model: variable Dbh excluded; 2nd model: Nrust5m excluded).

Multivariate PCA and LDA served to discriminate between groups (categories occupied nest sites, not occupied nest sites and random plots). In a PCA, the original data record is transformed into non-correlating variables called principal components (PC), which are sorted by their information content. Ideally, the transformation also leads to a reduction of dimensions of the data record. In a LDA, linear functions are searched to subdivide the original data into classes: objects within a class should exhibit as many common features as possible, while objects in different classes should have as few common features as possible. An important precondition for these analyses is that the data are normally distributed. Data volume in this analysis was sufficiently large to provide an approximation of the data to normal distribution, even though not all single variables were normally distributed. The PCA was performed with all variables except those that were not recorded at random plots. In a second go, not normally distributed variables were excluded. In a third go, random plots were excluded to try and show a better differentiation between occupied and not occupied nest sites.

3 Results

3.1 Breeding period and breeding success of Tawny Owls in the study area

Based on nine nests, a rough overview of the breeding biology of the Tawny Owls in the study area in the year 2011 can be given (Figure 10). Laying of eggs took place between the end of March and the middle of April, incubation lasted until the middle of May, hatching occurred between the end of April and the middle of May, and the nestling period stretched from the end of April until the middle of June. Fledging started at the end of May, but may have lasted until the end of June or longer.

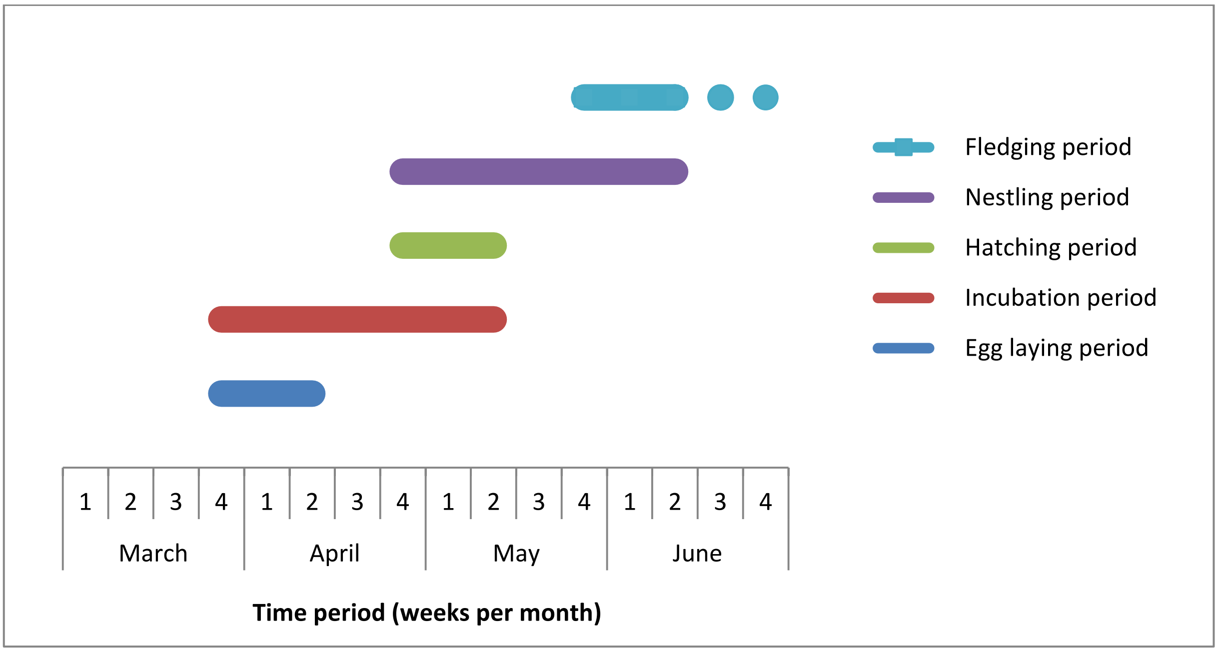

Figure 10: Breeding period of Tawny Owls in the Vienna Woods, based on nine examined broods.

Breeding success was defined as the number of nestlings in a nest at the time of the inspection. In 2011, it ranged from one to three young in the successful broods that were inspected. Three nesting boxes contained only one nestling, five boxes contained two nestlings, and only one box contained three nestlings. The mean breeding success therefore was 1.8 nestlings per inspected successful breeding pair (n = 9 of 24).

3.2 Habitat

An overview of the data collected about all the different habitat variables that were recorded at nest sites (occupied as well as not occupied) and random plots is presented in Table 3. Heightbox, Exposition, Rbio and Bbio are missing in the last column because they were not recorded at random plots.

Table 3: List of mean, standard deviation (SD), minimum and maximum of all habitat variables recorded at potential Tawny Owl nest sites as well as at random plots, calculated for not occupied nest sites, occupied nest sites, and random plots separately. Results are presented in each cell according to the following pattern: "mean ± SD (minimum – maximum)".

Variable	Not occupied boxes (n=36)	Occupied boxes (n=24)	Random plots (n=30)
Nest tree and nesting box/ Random tree			
Heightbox [m]	14.3 ± 3.5 (8.5 – 25)	13.8 ± 2.2 (10.0 – 19.0)	-

Table 3 – CONTINUED: List of mean, standard deviation (SD), minimum and maximum of all habitat variables recorded at potential Tawny Owl nest sites as well as at random plots, calculated for not occupied nest sites, occupied nest sites, and random plots separately. Results are presented in each cell according to the following pattern: "mean ± SD (minimum – maximum)".

Variable	Not occupied boxes (n=36)	Occupied boxes (n=24)	Random plots (n=30)
Exposition [°]	136 ± 76 (20 – 320)	159 ± 76 (20 – 330)	-
Altitude [m. a. s. l.]	424 ± 60 (321 – 549)	445 ± 73 (328 – 599)	409 ± 65 (295 – 516)
Dbh [cm]	59 ± 11 (42 – 95)	57 ± 10 (43 – 86)	31 ± 13 (5 – 56)
Heighttree [m]	36 ± 5 (28 – 47)	37 ± 7 (27 – 53)	22 ± 9 (7 – 39)
Canopy [%]	78 ± 19 (40 – 100)	76 ± 20 (30 – 100)	76 ± 26 (15 – 100)
Microhabitat (r= 20 m)			
Slope [°]	14 ± 8 (0 – 33)	16 ± 7 (0 – 26)	13 ± 8 (0 – 28)
Groundcover [%]	58 ± 39 (0 – 100)	51 ± 37 (0 – 100)	55 ± 42 (0 – 100)
Nrshrubs	1 ± 6 (0 – 38)	2 ± 9 (0 – 40)	5 ± 16 (0 – 80)
Heightshrubs [m]	0.2 ± 0.7 (0 – 3)	0.2 ± 0.6 (0.0 – 2.5)	0.4 ± 0.8 (0.0 – 2.8)
Nrust	183 ± 665 (0 – 4005)	229 ± 579 (0 – 2800)	264 ± 610 (0 – 3000)
Nrust5l	171 ± 667 (0 – 4001)	215 ± 583 (0 – 2800)	235 ± 605 (0 – 3000)
Nrust5m	12 ± 11 (0 – 42)	14 ± 13 (0 – 43)	30 ± 43 (0 – 240)
Heightust [m]	6.2 ± 4.7 (0 – 15.9)	4.7 ± 2.9 (0.0 – 10.9)	6.6 ± 4.3 (0.0 – 19.2)
Nrost	36 ± 12 (19 – 66)	45 ± 15 (16 – 69)	249 ± 480 (31 – 2240)
Nrost25	7 ± 7 (0 – 34)	14 ± 11 (0 – 36)	225 ± 490 (1 – 2240)
Nrost2540	15 ± 7 (1 – 29)	17 ± 8 (0 – 30)	13 ± 8 (0 – 25)
Nrost40	15 ± 5 (5 – 25)	13 ± 5 (4 – 24)	11 ± 10 (0 – 37)
Fag	28 ± 13 (0 – 52)	29 ± 18 (0 – 59)	139 ± 272 (0 – 1081)
Que	3 ± 8 (0 – 36)	6 ± 11 (0 – 43)	10 ± 43 (0 – 240)
Dec	3 ± 6 (0 – 30)	4 ± 5 (0 – 18)	92 ± 332 (0 – 1840)
Pic	1 ± 3 (0 – 13)	3 ± 7 (0 – 27)	4 ± 13 (0 – 60)
Conif	1 ± 2 (0 – 10)	3 ± 4 (0 – 16)	5 ± 11 (0 – 50)
Nrdead	12 ± 9 (0 – 36)	12 ± 11 (0 – 46)	54 ± 85 (0 – 320)
Nrdead25st	2 ± 4 (0 – 15)	3 ± 5 (0 – 19)	21 ± 39 (0 – 160)
Nrdead25l	6 ± 5 (0 – 19)	8 ± 7 (0 – 25)	32 ± 58 (0 – 280)
Nrdead2540st	1 ± 1 (0 – 3)	0 ± 0 (0 – 1)	0 ± 1 (0 – 5)
Nrdead2540l	2 ± 2 (0 – 10)	1 ± 1 (0 – 7)	1 ± 2 (0 – 8)
Nrdead40st	0 ± 0 (0 – 1)	0 ± 1 (0 – 3)	0 ± 0 (0 – 0)
Nrdead40l	1 ± 1 (0 – 4)	0 ± 0 (0 – 1)	0 ± 1 (0 – 2)
Macrohabitat (r = 250 m)			
Forest [%]	94 ± 8 (75 – 100)	93 ± 9 (65 – 100)	76 ± 22 (10 – 100)
Edge [m]	409 ± 369 (60 – 1550)	292 ± 189 (10 – 750)	198 ± 227 (20 – 875)
Water [m]	89 ± 85 (15 – 425)	134 ± 116 (10 – 450)	119 ± 81 (2 – 325)
Settlement [m]	698 ± 436 (150 – 1650)	828 ± 426 (250 – 1950)	432 ± 434 (50 – 1900)
Pavroad [m]	699 ± 362 (125 – 1600)	626 ± 322 (75 – 1150)	269 ± 277 (25 – 1100)
Unpavroad [m]	110 ± 59 (15 – 250)	95 ± 46 (50 – 200)	96 ± 73 (15 – 325)
Pavroadl [m]	46 ± 188 (0 – 1050)	40 ± 109 (0 – 450)	408 ± 438 (0 – 1950)
Unpavroadl [m]	760 ± 454 (0 – 1900)	610 ± 238 (150 – 1000)	643 ± 373 (0 – 1350)
Box [m]	1068 ± 610 (250 – 3350)	872 ± 833 (250 – 4280)	1465 ± 714 (350 – 3070)
Boxoc [m]	2351 ± 2048 (320 – 7360)	1855 ± 1722 (320 – 6500)	3089 ± 2047 (470 – 7140)
Rbio [g]	26 ± 44 (0 – 102)	9 ± 21 (0 – 67)	-
Bbio [g]	2552 ± 682 (1886 – 3743)	2614 ± 623 (1695 – 3743)	-

To show the incidence of outliers, a comparison between SD and MAD of all habitat variables recorded at nest sites and random plots was drawn in Table 4. The incidence of outliers can be read from this table because the SD is vulnerable to outliers whereas the MAD is not: if SD and MAD of a habitat variable differ greatly, many outliers occur in this variable. The comparison shows that only few outliers occur in habitat variables at the nesting box level. At the microhabitat level, several extreme outliers occur in Nrust and Nrust5l in all three categories. Most outliers appear in the random category (striking differences between SD and MAD in the variables Nrost, Nrost25, Fag, Que, Dec, Nrdead, Nrdead25st and Nrdead25l). Heightbox, Exposition, Rbio and Bbio are missing in the last column because they were not recorded at random plots.

Table 4: Comparison of standard deviation (SD) and mean absolute deviation (MAD) of habitat variables recorded at Tawny Owl nest sites as well as at random plots, calculated for not occupied nest sites (0), occupied nest sites (1) and random plots (2) separately.

Variable	0 (n = 36)		1 (n = 24)		2 (n = 30)	
	SD	MAD	SD	MAD	SD	MAD
Nest tree and nesting box/ Random tree						
Heightbox [m]	3.5	2.59455	2.2	1.4826	-	-
Exposition [°]	76	74.13	76	51.891	-	-
Altitude [m. a. s. l.]	60	51.891	73	85.2495	65	74.13
Dbh [cm]	11	5.9304	10	8.8956	13	14.826
Heighttree [m]	5	5.9304	7	7.413	9	8.8956
Canopy [%]	19	25.9455	20	25.9455	26	18.5325
Microhabitat (r = 20 m)						
Slope [°]	8	7.413	7	9.6369	8	9.6369
Groundcover [%]	39	40.7715	37	55.5975	42	44.478
Nrshrubs	6	0	9	0	16	0
Heightshrubs [m]	0.7	0	0.6	0	0.8	0
Nrust	665	38.5476	579	55.5975	610	72.6474
Nrust5l	667	14.0847	583	37.8063	605	47.4432
Nrust5m	11	10.3782	13	8.1543	43	17.7912
Heightust [m]	4.7	5.78214	2.9	2.2239	4.3	2.52042
Nrost	12	11.1195	15	16.3086	480	45.9606
Nrost25	7	4.4478	11	14.0847	490	49.6671
Nrost2540	7	7.413	8	7.413	8	9.6369
Nrost40	5	5.1891	5	4.4478	10	13.3434
Fag	13	12.6021	18	19.2738	272	41.5128
Que	8	0	11	0	43	2.9652
Dec	6	0	5	2.9652	332	31.1346
Pic	3	0	7	0	13	0
Conif	2	0	4	1.4826	11	0
Nrdead	9	7.413	11	10.3782	85	21.4977
Nrdead25st	4	1.4826	5	2.2239	39	6.6717
Nrdead25l	5	5.9304	7	6.6717	58	13.3434
Nrdead2540st	1	0	0	0	1	0
Nrdead2540l	2	1.4826	1	1.4826	2	0
Nrdead40st	0	0	1	0	0	0
Nrdead40l	1	0	0	0	1	0

Table 4 – CONTINUED: Comparison of standard deviation (SD) and mean absolute deviation (MAD) of habitat variables recorded at Tawny Owl nest sites as well as at random plots, calculated for not occupied nest sites (0), occupied nest sites (1) and random plots (2) separately.

Variable	0 (n = 36)		1 (n = 24)		2 (n = 30)	
	SD	MAD	SD	MAD	SD	MAD
Macrohabitat (r = 250 m)						
Forest [%]	8	3.7065	9	7.413	22	18.5325
Edge [m]	369	155.673	189	148.26	227	96.369
Water [m]	85	55.5975	116	88.956	81	92.6625
Settlement [m]	436	352.1175	426	333.585	434	333.585
Pavroad [m]	362	370.65	322	370.65	277	118.608
Unpavroad [m]	59	66.717	46	51.891	73	37.065
Pavroadl [m]	188	0	109	0	438	593.04
Unpavroadl [m]	454	259.455	238	333.585	373	407.715
Box [m]	610	296.52	833	318.759	714	837.669
Boxoc [m]	2048	859.908	1722	778.365	2047	2260.965
Rbio [g]	44	0	21	0	-	-
Bbio [g]	682	1140.1194	623	504.8253	-	-

Of the 60 nesting boxes examined, 24 (40 %) were occupied and 36 (60 %) were not (Figure 11).

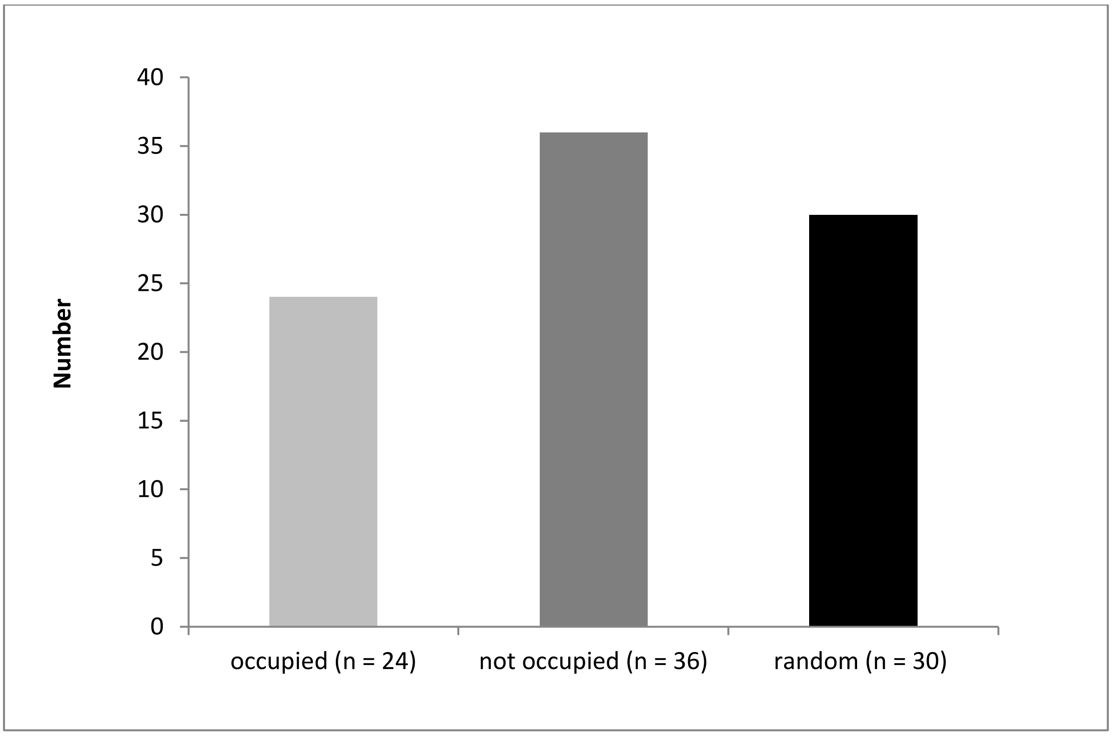

Figure 11: Frequency of the three occupation classes (nest sites occupied by Tawny Owls, nest sites not occupied by Tawny Owls, and random plots).

3.2.1 Habitat differences between occupied and not occupied nest sites

Significant differences between occupied and not occupied nest sites occur in six habitat variables. The number of overstory trees is higher in occupied habitats, especially the number of overstory trees < 25 cm, and also the number of other coniferous trees. Also important are the numbers of lying dead trees with diameters of 25-40 cm and >40 cm, which both are higher in not occupied habitats. At the macrohabitat level, only the distance to the nearest nesting box shows significant differences: it is smaller in occupied habitats than in not occupied ones. All significant and not significant results of Student's t-tests and Mann-Whitney-Wilcoxon-tests are listed in Table 5. Relationships to random plots will be dealt with in chapter 3.2.2 (p. 47).

Table 5: Comparison of normally (Student's t-test) and not normally (Mann-Whitney-Wilcoxon-test) distributed habitat variables of nest sites not occupied by Tawny Owls (0; n = 36), occupied nest sites (1; n = 24) and random points (2; n = 30). Value = t value or w value (Student's t-test or Mann-Whitney-Wilcoxon-test). *P<* = p value. - = data excluded from the tests. Significant results are marked in bold.

Variable	0 : 1		0 : 2		1 : 2	
	Value	*P<*	Value	*P<*	Value	*P<*
Nest tree and nesting box/ Random tree						
Heightbox [m]	438.0	0.9334	-	-	-	-
Exposition [°]	333.5	0.1386	-	-	-	-
Altitude [m. a. s. l.]	-1.2	0.2432	1.0	0.3448	1.9	0.0656
Dbh [cm]	479.0	0.4824	**1039.5**	**0.0000**	**8.4**	**0.0000**
Heighttree [m]	-1.1	0.2946	**7.2**	**0.0000**	**7.0**	**0.0000**
Canopy [%]	463.5	0.6374	540.0	1.0000	334.5	0.6596
Microhabitat (r = 20 m)						
Slope [°]	-0.8	0.4242	0.7	0.5143	1.4	0.1709
Groundcover [%]	461.0	0.6657	559.5	0.8047	347.5	0.8334
Nrshrubs	412.5	0.5819	492.0	0.2806	342.5	0.6320
Heightshrubs [m]	417.5	0.6849	497.5	0.3400	342.5	0.6320
Nrust	325.5	0.1096	406.0	0.0855	346.0	0.8142
Nrust5l	319.5	0.0899	435.5	0.1783	370.5	0.8616
Nrust5m	387.5	0.5061	**336.5**	**0.0088**	257.5	0.0753
Heightust [m]	486.5	0.4150	503.0	0.6382	269.0	0.1150
Nrost	**-2.3**	**0.0246**	**97.0**	**0.0000**	**143.5**	**0.0002**
Nrost25	**227.0**	**0.0020**	**139.5**	**0.0000**	**168.5**	**0.0009**
Nrost2540	-1.2	0.2410	561.0	0.7915	453.0	0.1068
Nrost40	1.3	0.2146	678.0	0.0762	420.0	0.2991
Fag	-0.2	0.8587	449.5	0.2463	301.0	0.3083
Que	408.0	0.6851	414.0	0.0836	316.0	0.4212
Dec	317.5	0.0571	**300.0**	**0.0008**	**240.0**	**0.0312**
Pic	388.0	0.3758	513.0	0.6331	375.0	0.7432
Conif	**303.0**	**0.0300**	476.5	0.3332	407.0	0.3779
Nrdead	449.5	0.7973	**317.0**	**0.0041**	**211.0**	**0.0097**
Nrdead25st	336.5	0.1369	**282.5**	**0.0007**	**246.0**	**0.0461**
Nrdead25l	419.0	0.8499	**283.5**	**0.0010**	**211.0**	**0.0096**
Nrdead2540st	517.5	0.1150	609.5	0.2825	336.5	0.5898
Nrdead2540l	**616.0**	**0.0041**	**785.5**	**0.0009**	415.5	0.2790
Nrdead40st	419.0	0.6626	-	-	-	-
Nrdead40l	**569.0**	**0.0078**	651.5	0.0767	317.0	0.2300
Macrohabitat (r = 250 m)						
Forest [%]	480.0	0.4506	**859.0**	**0.0000**	**556.5**	**0.0005**
Edge [m]	503.5	0.2832	**828.0**	**0.0002**	**506.5**	**0.0109**
Water [m]	340.0	0.1658	409.5	0.0929	368.5	0.8889
Settlement [m]	339.5	0.1646	**779.5**	**0.0021**	**571.5**	**0.0002**

Table 5 – CONTINUED: Comparison of normally (Student's t-test) and not normally (Mann-Whitney-Wilcoxon-test) distributed habitat variables of nest sites not occupied by Tawny Owls (0; n = 36), occupied nest sites (1; n = 24) and random points (2; n = 30). Value = t value or w value (Student's t-test or Mann-Whitney-Wilcoxon-test). *P<* = p value. - = data excluded from the tests. Significant results are marked in bold.

Variable	0 : 1		0 : 2		1 : 2	
	Value	*P<*	Value	*P<*	Value	*P<*
Pavroad [m]	0.8	0.4199	**914.5**	**0.0000**	**585.0**	**0.0001**
Unpavroad [m]	498.0	0.3173	648.0	0.1637	395.0	0.5425
Pavroadl [m]	408.5	0.5569	**261.0**	**0.0000**	**172.0**	**0.0002**
Unpavroadl [m]	467.0	0.6016	587.5	0.5443	-0.4	0.6957
Box [m]	**594.5**	**0.0145**	**332.0**	**0.0075**	**153.0**	**0.0003**
Boxoc [m]	502.0	0.2941	395.0	0.0627	**210.0**	**0.0093**
Rbio [g]	485.0	0.2964	-	-	-	-
Bbio [g]	394.0	0.5594	-	-	-	-

3.2.1.1 Variable "Position"

The nominal variable Position also differs between occupied and not occupied nest sites. At hilltop and at the foot of the slope, only few and only not occupied nest sites occur (n = 3 and n = 2, respectively). Occupied nest sites only occur uphill and downhill, and their numbers are about one third lower downhill than uphill (10 and 14 nests, respectively). The number of not occupied nest sites located uphill is more than twice the number located downhill (22 and 9 sites, respectively) (Figure 12). Considering the total number of nesting boxes available each at the positions uphill and downhill, however, Tawny Owls bred slightly more often downhill (53 % of available nesting boxes occupied vs. 47 % not occupied, n = 36) than uphill (39 % occupied vs. 61 % not occupied, n = 19).

In an ANOVA, no significant differences between occupied and not occupied nest sites in the nominal variable Position were discovered (p = 0.2207, see Table 6).

3.2.1.2 Variable "Species"

As seen in Figure 13, nest tree species in occupied habitats mainly belong to the species European Beech *Fagus sylvatica* (92 %, n = 22 out of 24). The rest (8 %) belongs to the genus Oak *Quercus* spp. In not occupied habitats, the number of beech trees is even higher (n = 31 of 36), but it amounts to only 86 % because there are also more oaks (n = 3) as well as two Maples *Acer* spp. (8 % and 6 %, respectively).

For the results of the ANOVA, see Table 6. No significant p value was obtained (p = 0.7458).

Table 6: Results of the separate ANOVAs of the habitat variables Position and Species for nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36). *P<* = p value.

Variable	*P<*
Position	0.2207
Species	0.7458

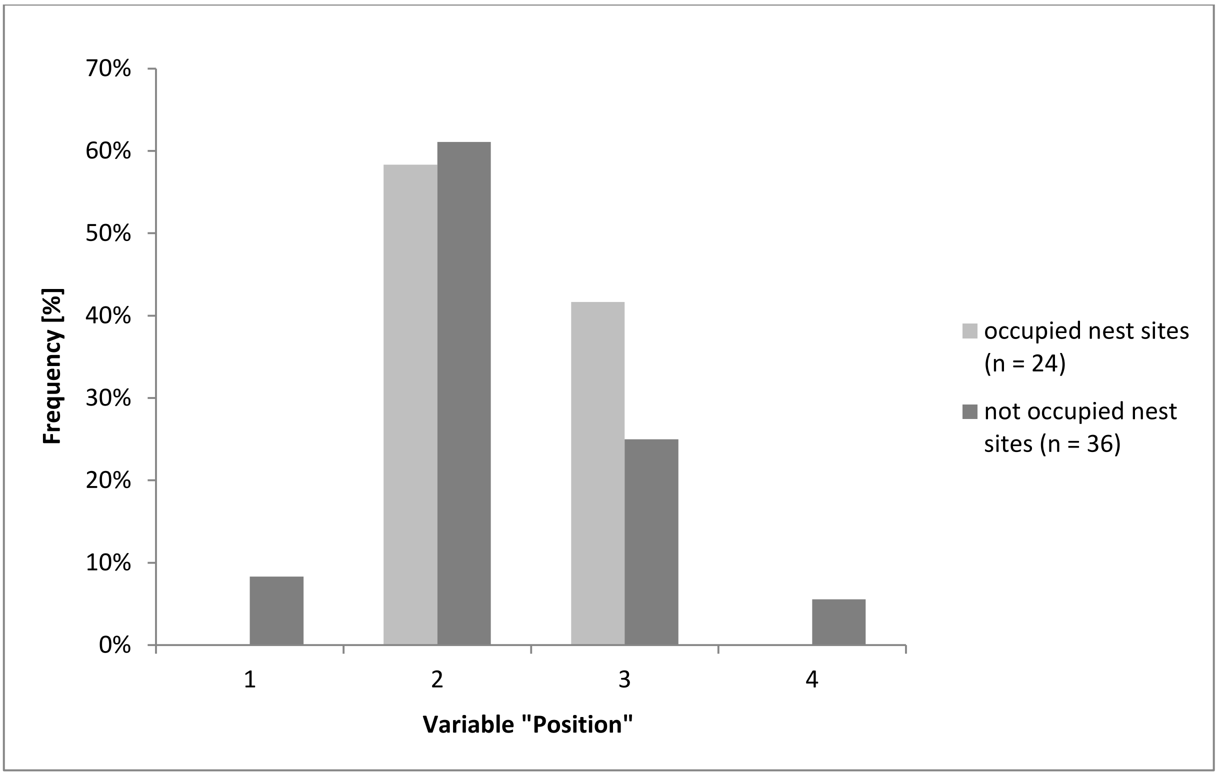

Figure 12: Comparison of nest sites occupied by Tawny Owls and not occupied nest sites in relation to position on the slope. Frequency given as percentage of occupied / not occupied nest sites located at each position. 1 = hilltop; 2 = uphill; 3 = downhill; 4 = foot of the slope. Red = occupied nest sites; green = not occupied nest sites.

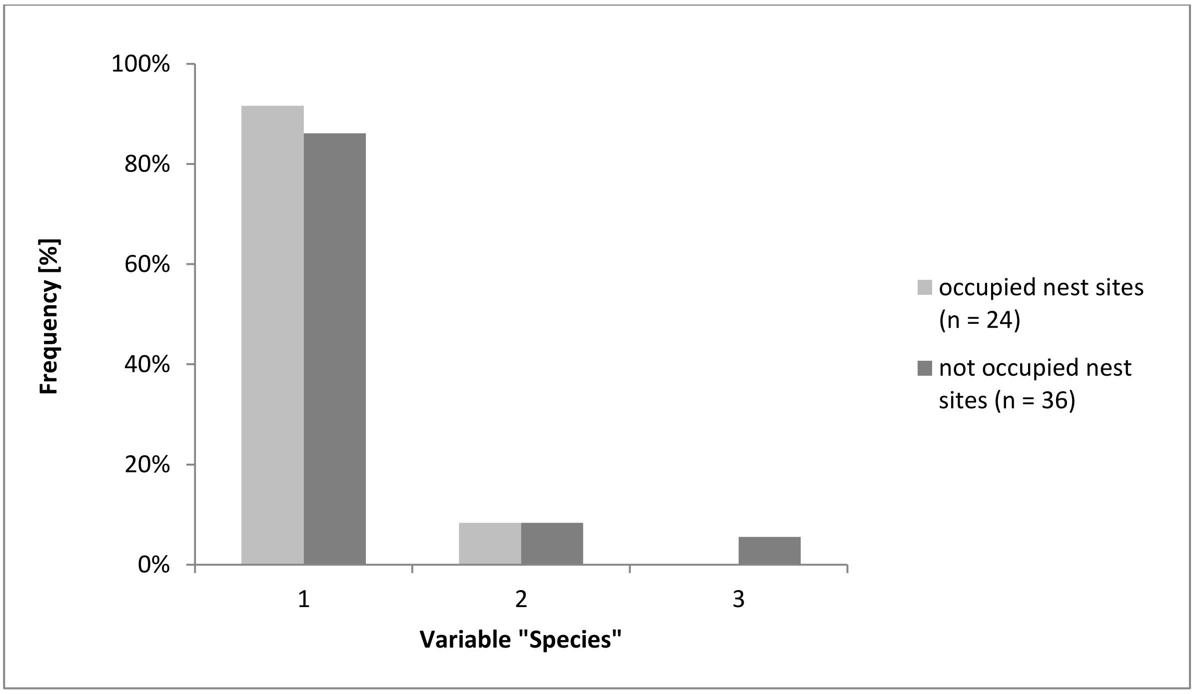

Figure 13: Comparison of the frequency of the three nest tree species recorded in the two categories nest sites occupied by Tawny Owls (red) and not occupied nest sites (green). 1 = European Beech *Fagus sylvatica*; 2 = Oak *Quercus* spp.; 3 = Maple *Acer* spp.

Table 7: Results of the separate logistic regressions comparing habitat variables between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36). A positive estimate value means that the concerned habitat variable is higher in the occupied class than in the not occupied class; if the estimate value is negative, it's vice versa. *P<* = p value. Significant results are marked in bold: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Variable	Estimate	*P<*
Exposition	0.003965	0.2612
Heightbox	-0.05917	0.5120
Rbio	-0.014742	0.0961
Bbio	0.0001457	0.7190
Altitude	0.005047	0.2200
Slope	0.02899	0.4260
Canopy	-0.005739	0.6780
Groundcover	-0.004504	0.5180
Dbh	-0.02235	0.3880
Heighttree	0.04968	0.2630
Nrshrubs	0.02272	0.5310
Heightshrubs	0.01224	0.9750
Nrust5l	0.0001079	0.7950
Nrust5m	0.01604	0.4570
Heightust	-0.09827	0.1580
Nrost25	**0.09512**	**0.0046 ****
Nrost2540	0.04195	0.2264
Nrost40	-0.06394	0.2210
Fag	0.003452	0.8460
Que	0.03612	0.2275
Dec	0.03443	0.4643
Pic	0.07653	0.2105
Conif	0.1764	0.0516
Nrdead25l	0.03124	0.4720
Nrdead25st	0.07746	0.2410
Nrdead2540l	-0.4665	0.0628
Nrdead2540st	-0.8911	0.0949
Nrdead40l	**-1.638848**	**0.0318 ***
Nrdead40st	0.6112	0.3763
Forest	-0.01806	0.5790
Edge	-0.001501	0.1760
Water	0.004533	0.1060
Settlement	0.0007041	0.2551
Pavroad	-0.0006249	0.4240
Unpavroad	-0.005355	0.3030
Pavroadl	-0.0002529	0.8820
Unpavroadl	-0.0011244	0.1520
Box	-0.0004651	0.3060
Boxoc	-0.0001445	0.3290

Separate logistic regressions confirmed parts of the results of the Student's t-tests and Mann-Whitney-Wilcoxon-tests. In this analysis, the number of overstory trees < 25 cm and the number of lying dead trees > 40 cm differed significantly between occupied and not occupied nest sites, too.

Nrost25 was significantly higher at occupied nest sites, while Nrdead40l was significantly higher at not occupied nest sites (Table 7).

In the following assembled logistic regression including only the two variables which produced significant results in the separate logistic regressions, only the number of overstory trees < 25 cm again procured a significant result, whereas the number of dead trees > 40 cm lying did not differ significantly any more (Table 8).

Table 8: Results of the assembled logistic regression comparing only those habitat variables showing significant results in the separate logistic regression between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36). A positive estimate value means that the concerned habitat variable is higher in the occupied class than in the not occupied class; if the estimate value is negative, it's vice versa. *P<* = p value. Significant results are marked in bold: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Variable	Estimate	*P<*
Nrost25	**0.06943**	**0.0456 ***
Nrdead40l	-1.16958	0.1257

For better illustration, the significant results of all analyses (Nrost, Nrost25, Conif, Nrdead2540l, Nrdead40l, Box) are shown in boxplots (Figure 14). * = p < 0.05; ** = p < 0.01; *** = p < 0.001. The highest significance level occurring in any analysis was transferred to the corresponding boxplot.

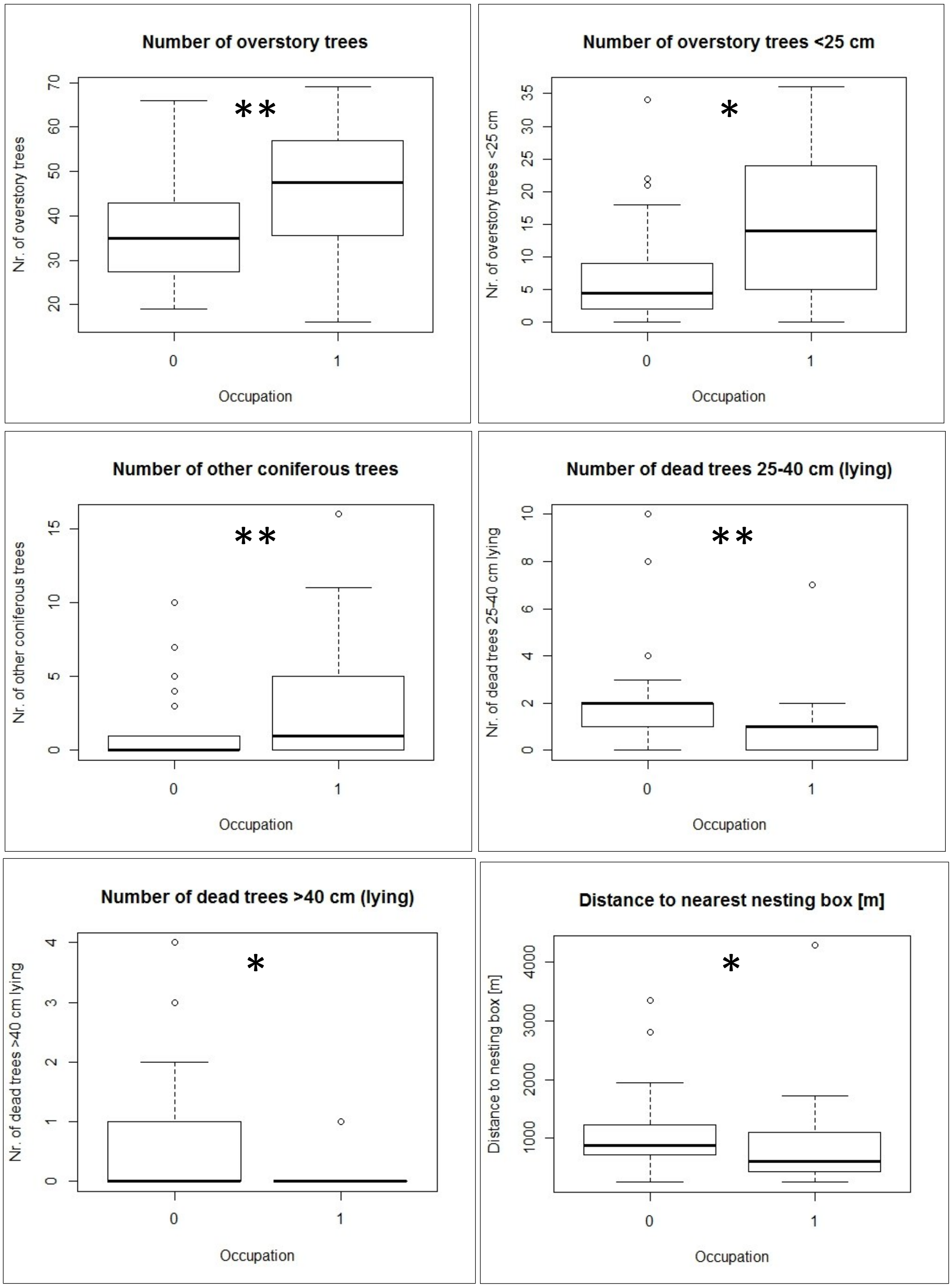

Figure 14: Boxplots of six habitat variables showing significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) using Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions (see text). * = p < 0.05; ** = p < 0.01; *** = p < 0.001. 0 = not occupied nest sites; 1 = occupied nest sites; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

In the PCA containing only those variables that were recorded at occupied and not occupied nest sites as well as at random plots, 40 principal components (PCs) were determined. The bar chart in Figure 15 illustrates the variance explained by each PC separately. PC1 explaining most of the variance (7.4, corresponding to 18 %) is located at the very left, followed by PC2 explaining 4.0 (10 %), and PC40 at the very right explaining only 3.6^{-32} of variance. PC1 and PC2 together explain 28 % of variance, the first eleven PCs together explain 71 %, and the first 15 PCs explain 81 %. To explain 95 % of variance, 25 PCs are needed.

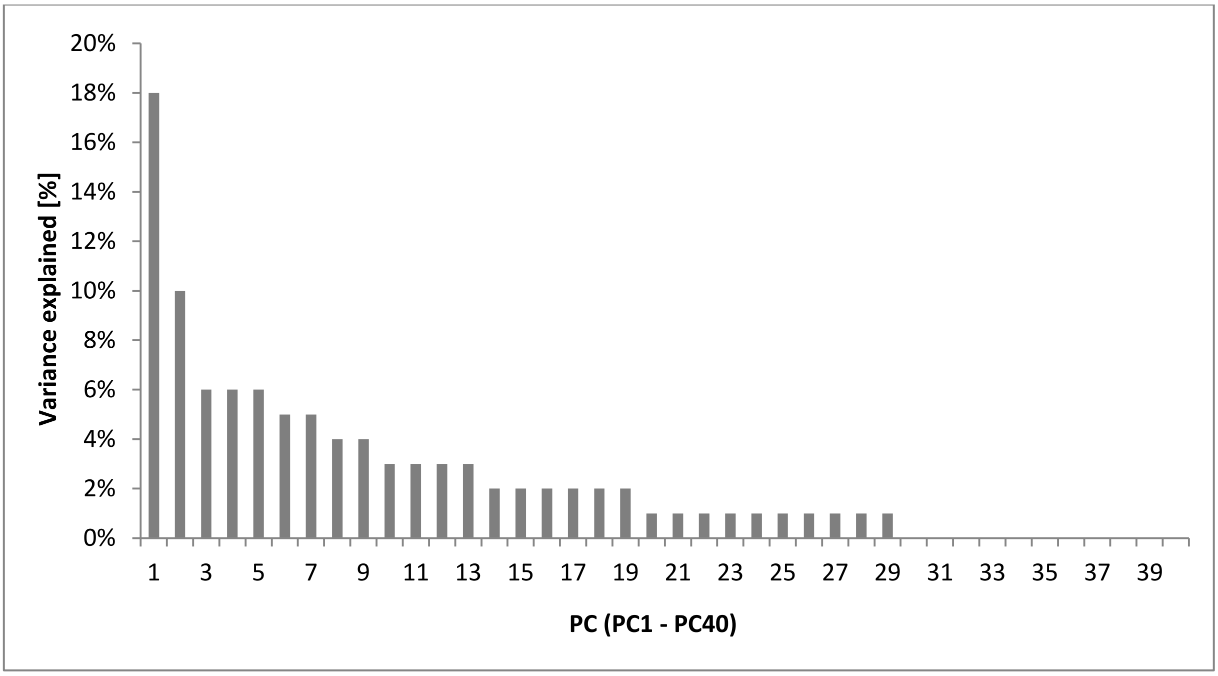

Figure 15: Bar chart illustrating how much variance (in %) is explained by each PC (principal component) in the PCA (principal component analysis) comparing habitat variables between nest sites occupied by Tawny Owls (n = 24), not occupied nest sites (n = 36) and random plots (n = 30). Each bar represents one PC; PCs are numbered consecutively from left (PC1) to right (PC40) on the x-axis.

Habitat variables number of overstory trees (Nrost), number of overstory trees < 25 cm (Nrost25), number of dead trees (Nrdead) and number of dead trees < 25 cm lying (Nrdead25l) exerted the strongest influence on PC1. PC2 was most influenced by forest cover (-Forest), distance to nearest paved road (-Pavroad) and length of paved road (Pavroadl) (Table 9). All of the variables mentioned were higher at random plots than at nest sites (except forest cover and distance to nearest paved road), but no statement can be made about the differences between occupied and not occupied nest sites because they overlap almost completely.

For graphic illustration of group separation, the two most important PCs were plotted against each other (PC1 against PC2, Figure 16). Three different colours represent the three categories occupied nest site, not occupied nest site, and random plot. Category random (blue) exhibits a broad spreading, and apart from a small overlap differs clearly from categories occupied nest site (red) and not occupied nest site (green). The latter two, however, show a strong overlap, although the category occupied nest site is slightly more compact.

The two additional PCAs (one excluding not normally distributed variables, the other excluding random plots) didn’t show clearer results than the first PCA, so their results are shown only in Appendix 6-11 to Appendix 6-14.

Table 9: Rotation of habitat variables for principal components 1 (PC1) and 2 (PC2). A minus sign means that the concerned habitat variable is higher at nest sites than at random plots. Habitat variables exerting the strongest influence on PC1 or PC2 are marked in bold.

Variable	PC1	PC2
Position	0,0495168650	0,1434094060
Species	0,1424954290	0,2441357830
Altitude	0,0155695330	-0,2153177830
Slope	-0,0351018820	-0,0280240170
Canopy	0,0054680710	-0,1251031860
Groundcover	-0,0854550560	0,1077822540
Dbh	-0,2620665490	-0,1089851470
Heighttree	-0,2693156020	-0,0985785460
Nrshrubs	0,0114894140	0,1761122760
Heightshrubs	-0,0046378810	0,1673296310
Nrust	0,0432780060	-0,1024931040
Nrust5l	0,0341933760	-0,1060588310
Nrust5m	0,2039891270	0,0786509550
Heightust	-0,0380104170	0,0985571480
Nrost	**0,3299549580**	-0,1019466990
Nrost25	**0,3319802800**	-0,1014033150
Nrost2540	-0,1374469520	0,0578035760
Nrost40	-0,1993830790	-0,0029568300
Fag	0,2728277970	-0,1757432550
Que	0,1843504210	-0,1143746600
Dec	0,2326060470	0,0155353980
Pic	0,1439188960	-0,0784895110
Conif	0,0381147810	-0,0266273790
Nrdead	**0,3199978850**	-0,0941611750
Nrdead25st	0,2483484660	-0,0486021850
Nrdead25l	**0,3166736130**	-0,1146813240
Nrdead2540st	-0,0183681790	0,1537987020
Nrdead2540l	-0,0827746590	0,0261571550
Nrdead40st	-0,0289042940	0,0090362890
Nrdead40l	-0,0645388530	0,0948921310
Forest	-0,0845257030	**-0,4014227940**
Edge	-0,0744494260	-0,2532636940
Water	0,0101794690	0,0793519190
Settlement	-0,0674483290	-0,2875123890
Pavroad	-0,1238981150	**-0,3319556260**
Unpavroad	-0,0303804540	-0,0475750010
Pavroadl	0,0791623500	**0,3447757900**
Unpavroadl	-0,0143998910	-0,0241379170
Box	0,0251728450	0,1856760330
Boxoc	0,0358835260	0,1166853600

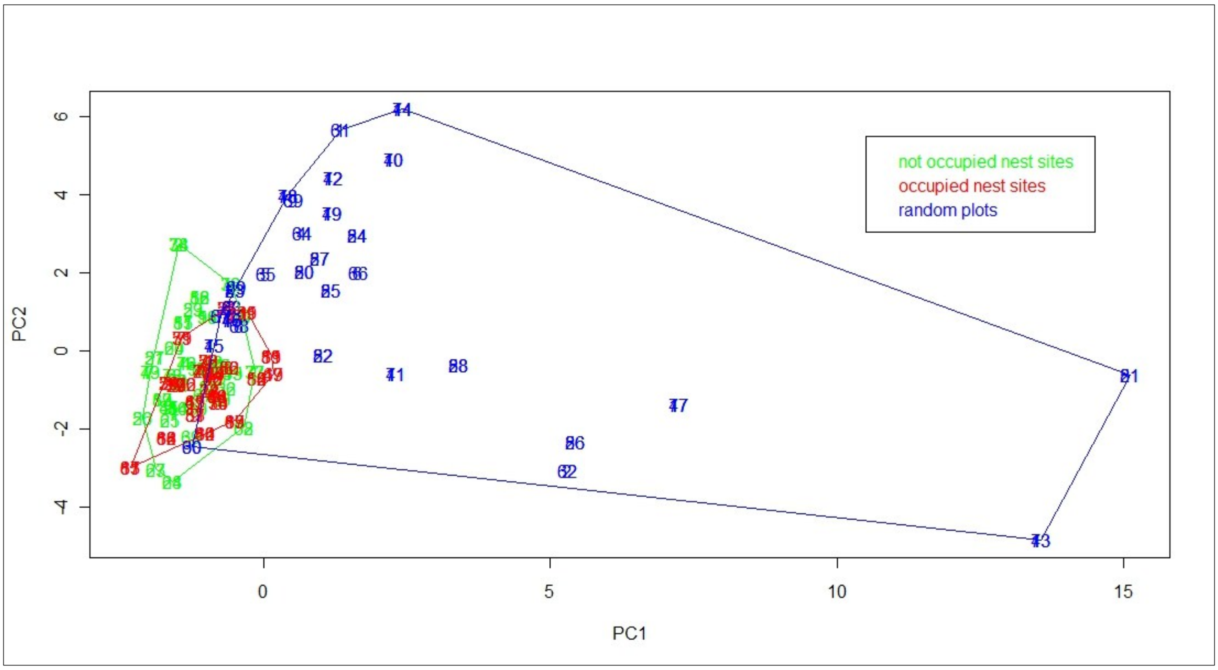

Figure 16: Plot of PC1 (x-axis) against PC2 (y-axis) showing group separation of nest sites occupied by Tawny Owls (red; n = 24), not occupied nest sites (green; n = 36) and random plots (blue; n = 30).

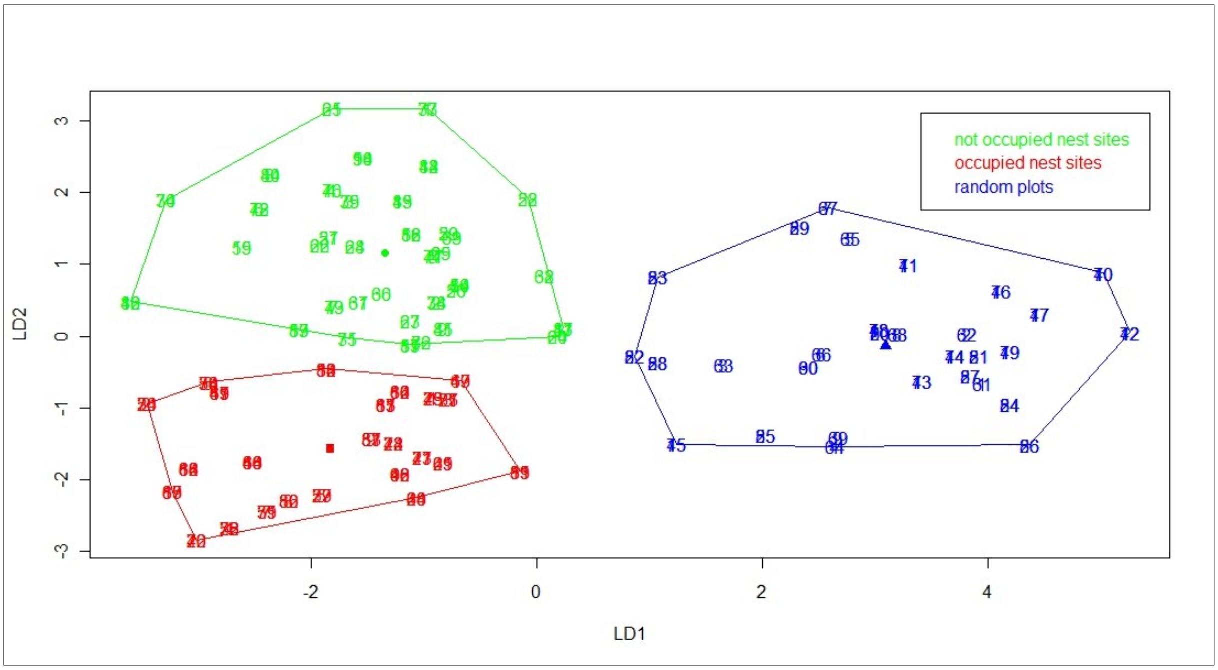

Figure 17: Plot of LD1 (x-axis) against LD2 (y-axis), showing a discernible group separation of sites (n = 90) classified as occupied by Tawny Owls (red; n = 24), as not occupied nest sites (green; n = 36), and as random plots (blue; n = 30). Green dot = group mean of not occupied nest sites; red square = group mean of occupied nest sites; blue triangle = group mean of random plots.

Table 10: Discriminant scores of habitat variables for linear discriminants 1 (LD1) and 2 (LD2). A minus sign means that the concerned habitat variable is higher at random plots than at nest sites (LD1), or higher at not occupied nest sites than at occupied nest sites (LD2). Habitat variables exerting the strongest influence on LD1 or LD2 are marked in bold.

Variable	LD1	LD2
Position	0,0342996300	-0,3524556000
Species	0,2227865000	0,2505360000
Altitude	-0,0055998930	-0,0024213030
Slope	0,0010414170	-0,0382619800
Canopy	0,0116853000	0,0130796900
Groundcover	0,0110503600	-0,0030498270
Dbh	-0,0744051600	0,0139063100
Heighttree	-0,0666474200	-0,0824584300
Nrshrubs	-0,0236567300	0,0171562000
Heightshrubs	**0,3798231000**	-0,1410573000
Nrust	0,0001466384	-0,0002427832
Nrust5l	0,0001805141	-0,0001696388
Nrust5m	-0,0185202100	-0,0399571500
Heightust	0,0780412000	0,0649922500
Nrost	0,1984264000	0,4306478000
Nrost25	0,1904225000	0,4133873000
Nrost2540	0,1998624000	0,4031273000
Nrost40	0,2508898000	0,4131762000
Fag	**-0,3888442000**	**-0,8467296000**
Que	**-0,4312937000**	**-0,8220227000**
Dec	**-0,3895227000**	**-0,8382413000**
Pic	**-0,3522064000**	**-0,8349788000**
Conif	**-0,3450166000**	**-0,8921857000**
Nrdead	0,0080904000	-0,0034597940
Nrdead25st	-0,0216991800	0,0150134100
Nrdead25l	0,0273783400	-0,0152206300
Nrdead2540st	-0,2781326000	0,1092540000
Nrdead2540l	0,0479288500	0,1865274000
Nrdead40st	-0,0715052700	**-0,7332804000**
Nrdead40l	**-0,3595566000**	**0,9832255000**
Forest	-0,0380918100	0,0120132400
Edge	0,0005661194	0,0024750480
Water	-0,0026229770	-0,0041745310
Settlement	-0,0007234084	-0,0005987707
Pavroad	-0,0004216297	0,0005122922
Unpavroad	0,0035261870	0,0047429610
Pavroadl	-0,0001534353	0,0000900918
Unpavroadl	0,0002096568	0,0012201180
Box	0,0004021513	0,0003194485
Boxoc	0,0000133240	0,0000726601

In contrast, the classification of habitat variables recorded at occupied and not occupied nest sites as well as at random plots in a LDA resulted in a clear group separation (see Figure 17). Occupied and not occupied nest sites completely overlap in LD1, but are clearly separated in LD2, whereas random plots overlap with both occupied and not occupied nest sites in LD2, but are clearly segregated from them in LD1. Only 10 % (n = 6 of 60) of nest sites were classified in the wrong group, whereas all random plots were correctly classified as random plots, resulting in an overall classification error of 7 % (n = 90).

The numbers of different tree species in the microhabitat were most important for both LD1 and LD2. LD1 divides the three groups by means of tree species composition (-Fag, -Que, -Dec, -Pic, -Conif), lying dead trees with large diameters (-Nrdead40l), and height of shrubs (+Heightshrubs). In LD2, the allocation of sites to the three groups is also based on tree species composition (-Fag, -Que, -Dec, -Pic, -Conif). However, the number of standing dead trees with large diameters (-Nrdead40st) is of importance too, as well as the number of lying dead trees with large diameters (+Nrdead40l), which in LD2, unlike in LD1, has a plus sign.

This means that the numbers of all the different tree species, as well as the number of lying dead trees with large diameters were higher at random plots than at nest sites. Additionally, height of shrubs was usually lower at random plots than at nest sites (LD1). The division of occupied and not occupied nest sites on the y-axis (LD2) showed some similarities in relevant habitat characters. At not occupied nest sites, the numbers of all the different tree species and the number of standing dead trees with large diameters were higher than at occupied nest sites. The number of lying dead trees with large diameters, on the other hand, was lower at not occupied nest sites than at occupied Tawny Owl nests (Table 9).

3.2.2 Habitat differences between nest sites and random plots

A considerable number of nest sites (occupied as well as not occupied) and random plots differ significantly. Most pronounced differences occur in the variables Dbh and Heighttree (both higher in nest sites than in random points), and Nrost, especially in Nrost25 (both lower in nest sites). The three macrohabitat variables Forest (higher in nest sites), Pavroad and Pavroadl also show pronounced differences: the distance to the nearest paved road is larger in nest sites than in random plots, and consequently the length of paved roads is shorter in nest sites.

Less pronounced but still significant differences appear in Dec, in Nrdead, especially in Nrdead25st and Nrdead25l (all four variables are lower in nest sites than in random plots), and in Settlement (higher in nest sites) and Box (lower in nest sites than in random plots).

An imbalance occurs in some variables as only either occupied or not occupied nest sites show significant otherness compared to random plots. The variable Nrust5m is significantly lower in not occupied nest sites than in random plots, Nrdead2540l and Edge are significantly higher in not occupied nest sites. The variable Boxoc is significantly lower in occupied nest sites than in random plots.

All other variables do not show significant differences between nest sites and random plots (Table 5, p. 37).

3.2.2.1 Variable "Position"

Both nest sites and random plots are rarely found at the hilltop or the foot of the slope (8 % of nest sites, 17 % of random plots, see Figure 18). Twice as many nest sites are found uphill (60 %) as downhill (32 %), while more random plots are found downhill (47 %) than uphill (37 %).

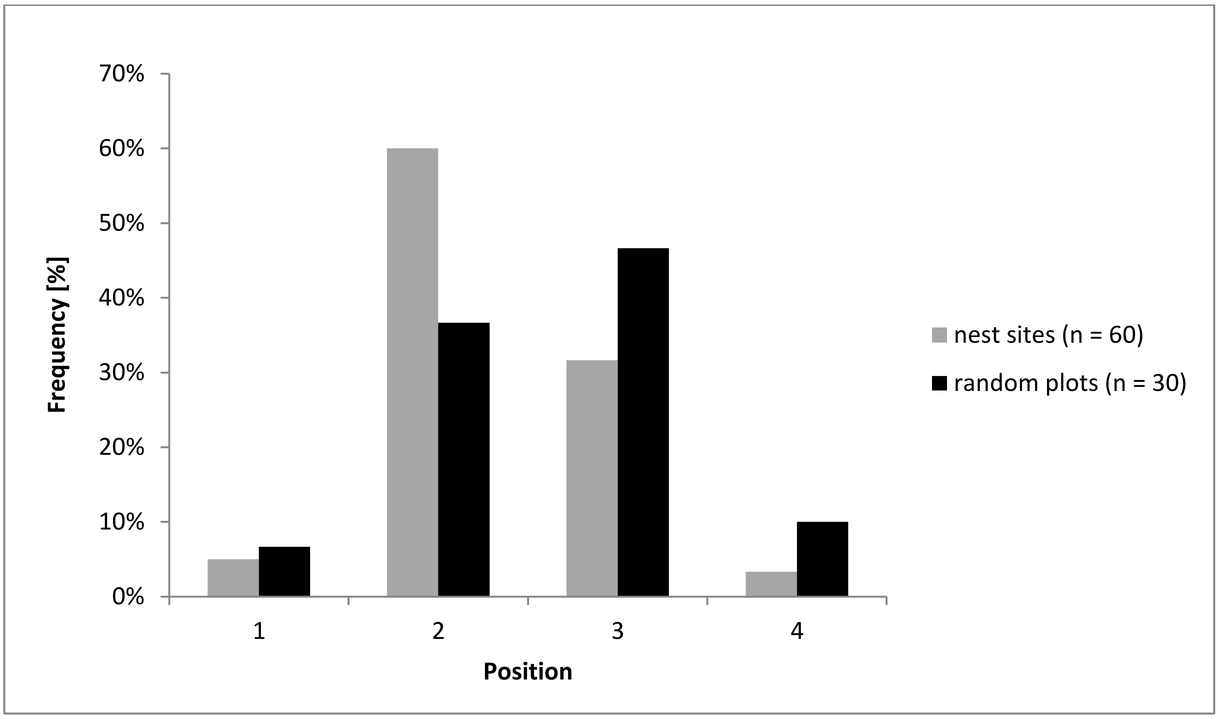

Figure 18: Comparison of the frequency of the four position classes hilltop (1), uphill (2), downhill (3) and foot of the slope (4) recorded in the two categories potential nest sites of Tawny Owls (yellow) and random plots (blue).

Although the differences are not significant, they show a strong trend (ANOVA, p = 0.1088) (Table 11).

Table 11: Results of the separate ANOVAs of the habitat variables Position and Species for all potential nest sites of Tawny Owls (n = 60) and random plots (n = 30). *P<* = p value.

Variable	*P<*
Position	0.1088
Species	**0.0022 ****

3.2.2.2 Variable "Species"

A noticeable dissimilarity between the species of nest trees and that of random trees exists. The diversity of different species is clearly higher in random trees, which belong to nine different species, predominantly beech (53 %) and European Hornbeam (20 %). Nest trees (selected by humans) are mostly represented by beech (88 %), the rest belong to oak (8 %) and maple (3 %, Figure 19).

Tree species also differ clearly between nest sites and random plots according to an ANOVA (p = 0.0022, Table 11). The diversity of species is significantly higher at random plots than at nest sites.

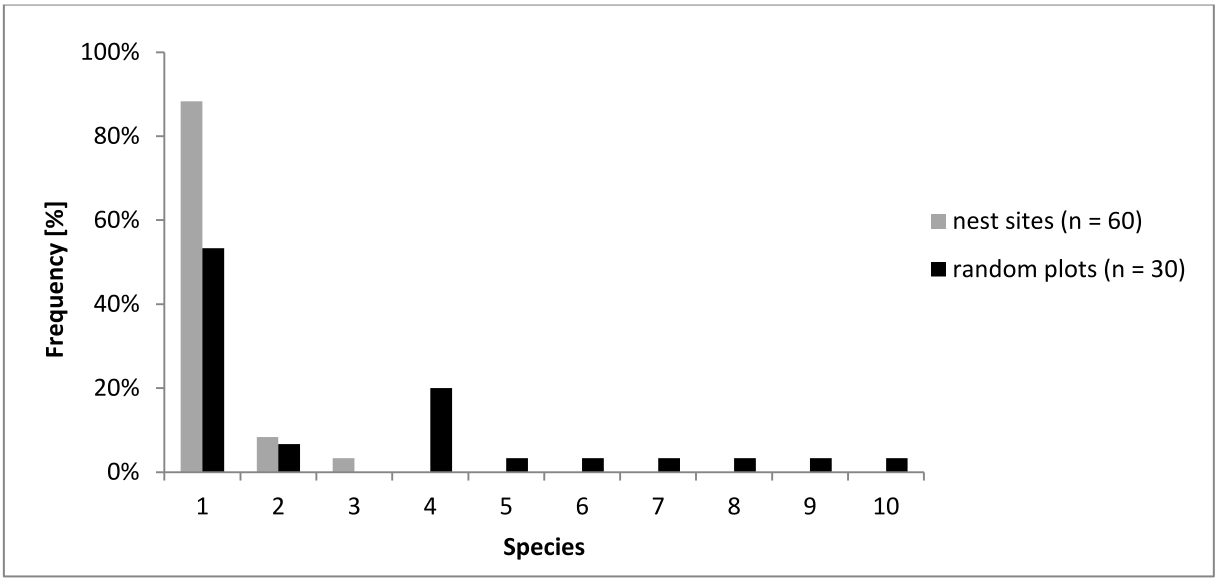

Figure 19: Comparison of the frequency of the ten tree species recorded in the two categories potential nest sites of Tawny Owls (yellow) and random plots (blue). 1 = European Beech *Fagus sylvatica*; 2 = Oak *Quercus* spp.; 3 = Maple *Acer* spp.; 4 = European Hornbeam *Carpinus betulus*; 5 = Norway Spruce *Picea abies*; 6 = European Ash *Fraxinus excelsior*; 7 = Douglas-Fir *Pseudotsuga menziesii*; 8 = Wild Cherry *Prunus avium*; 9 = European Larch *Larix decidua*; 10 = Elm *Ulmus* spp.

The logistic regression examining habitat variables of nest sites and random plots separately revealed a total of 14 habitat variables differing significantly between the two groups (Table 12). Especially the seven variables Dbh, Heighttree, Nrost25, Dec, Forest, Pavroad and Pavroadl are outstanding because they all show p values < 0.001 (***).

In the two assembled logistic regression models including only variables showing significant p values in the separate analyses, only some variables again showed significant p values: in the first assembled model (excluding the variable Dbh), Heighttree was the only significant variable (Table 13). In the second assembled model (Nrust5m excluded), Dbh, Nrost25, Dec, Forest and Settlement had significant p values (Table 14).

Table 12: Results of the separate logistic regressions comparing habitat variables between all potential nest sites of Tawny Owls (n = 60) and random plots (n = 30). A positive estimate value means that the concerned habitat variable is higher in the nest site class than in the random plot class; if the estimate value is negative, it's vice versa. *P<* = p value. Significant results are marked in bold: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Variable	Estimate	*P<*
Altitude	0.005631	0.1180
Slope	0.03337	0.2670
Canopy	0.003946	0.7030
Groundcover	0.0001638	0.9772
Dbh	**0.26792**	**0.0000 *** **
Heighttree	**0.32725**	**0.0000 *** **
Nrshrubs	-0.02858	0.1934
Heightshrubs	-0.2416	0.4082
Nrust5l	-0.0001165	0.7387
Nrust5m	**-0.04660**	**0.0051 ** **
Heightust	-0.05697	0.2862
Nrost25	**-0.07338**	**0.0006 *** **
Nrost2540	0.03393	0.2280
Nrost40	0.05746	0.0774
Fag	-0.014321	0.1019
Que	-0.008277	0.3887
Dec	**-0.08518**	**0.0006 *** **
Pic	-0.03504	0.2199
Conif	-0.06960	0.0922
Nrdead25st	**-0.10557**	**0.0150 * **
Nrdead25l	**-0.10107**	**0.0024 ** **
Nrdead2540st	-0.02886	0.9215
Nrdead2540l	0.1810	0.2167
Nrdead40st	15.8294	0.9904
Nrdead40l	0.3876	0.2870
Forest	**0.09231**	**0.0002 *** **
Edge	**0.003144**	**0.0187 * **
Water	-0.001316	0.5750
Settlement	**0.0020174**	**0.0035 ** **
Pavroad	**0.0040656**	**0.0000 *** **
Unpavroad	0.002130	0.5790
Pavroadl	**-0.004881**	**0.0000 *** **
Unpavroadl	0.0004040	0.5050
Box	**-0.0008983**	**0.0082 ** **
Boxoc	**-0.0002284**	**0.0402 * **

Table 13: Results of the first assembled logistic regression comparing only those habitat variables (except variable Dbh) showing significant results in the separate logistic regression between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30). A positive estimate value means that the concerned habitat variable is higher in the nest site class than in the random plot class; if the estimate value is negative, it is vice versa. *P<* = p value. Significant results are in bold: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Variable	Estimate	*P<*
Heighttree	**0.4747**	**0.00948 ** **
Nrust5m	0.03308	0.58023
Nrost25	-0.04884	0.52370
Dec	-0.1987	0.06471
Nrdead25l	-0.1535	0.17064
Nrdead25st	0.2393	0.31418
Forest	0.06915	0.33682
Edge	-0.004128	0.17589
Settlement	0.005040	0.06863
Pavroad	-0.001051	0.64773
Pavroadl	-0.006315	0.06069
Box	-0.001172	0.25703
Boxoc	0.0001408	0.74001

Table 14: Results of the second assembled logistic regression comparing only those habitat variables (except variable Nrust5m) showing significant results in the separate logistic regression between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30). A positive estimate value means that the concerned habitat variable is higher in the nest site class than in the random plot class; if the estimate value is negative, it is vice versa. *P<* = p value. Significant results are marked in bold: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Variable	Estimate	*P<*
Dbh	**0.6416**	**0.000936 *** **
Heighttree	0.1425	0.168608
Nrost25	**-0.1935**	**0.028508 * **
Dec	**-0.2801**	**0.000583 *** **
Nrdead25l	0.1458	0.160155
Nrdead25st	0.4436	0.082323
Forest	**-0.1341**	**0.043624 * **
Edge	-0.005798	0.093482
Settlement	**0.01239**	**0.000396 *** **
Pavroad	0.0003620	0.840516
Pavroadl	-0.001587	0.441142
Box	-0.001079	0.282602
Boxoc	-0.0001172	0.742803

For better illustration, the significant results of all analyses performed are shown as boxplots. Figure 20 - Figure 22 represent each of the 17 variables with significant differences in any of the analyses (Dbh, Heighttree, Nrust5m, Nrost, Nrost25, Dec, Nrdead, Nrdead25st, Nrdead25l, Nrdead2540l, Forest, Edge, Settlement, Pavroad, Pavroadl, Box, Boxoc). Significance levels are defined as * = p < 0.05; ** = p < 0.01; *** = p < 0.001. The highest significance level occurring in any analysis was transferred to the corresponding boxplot.

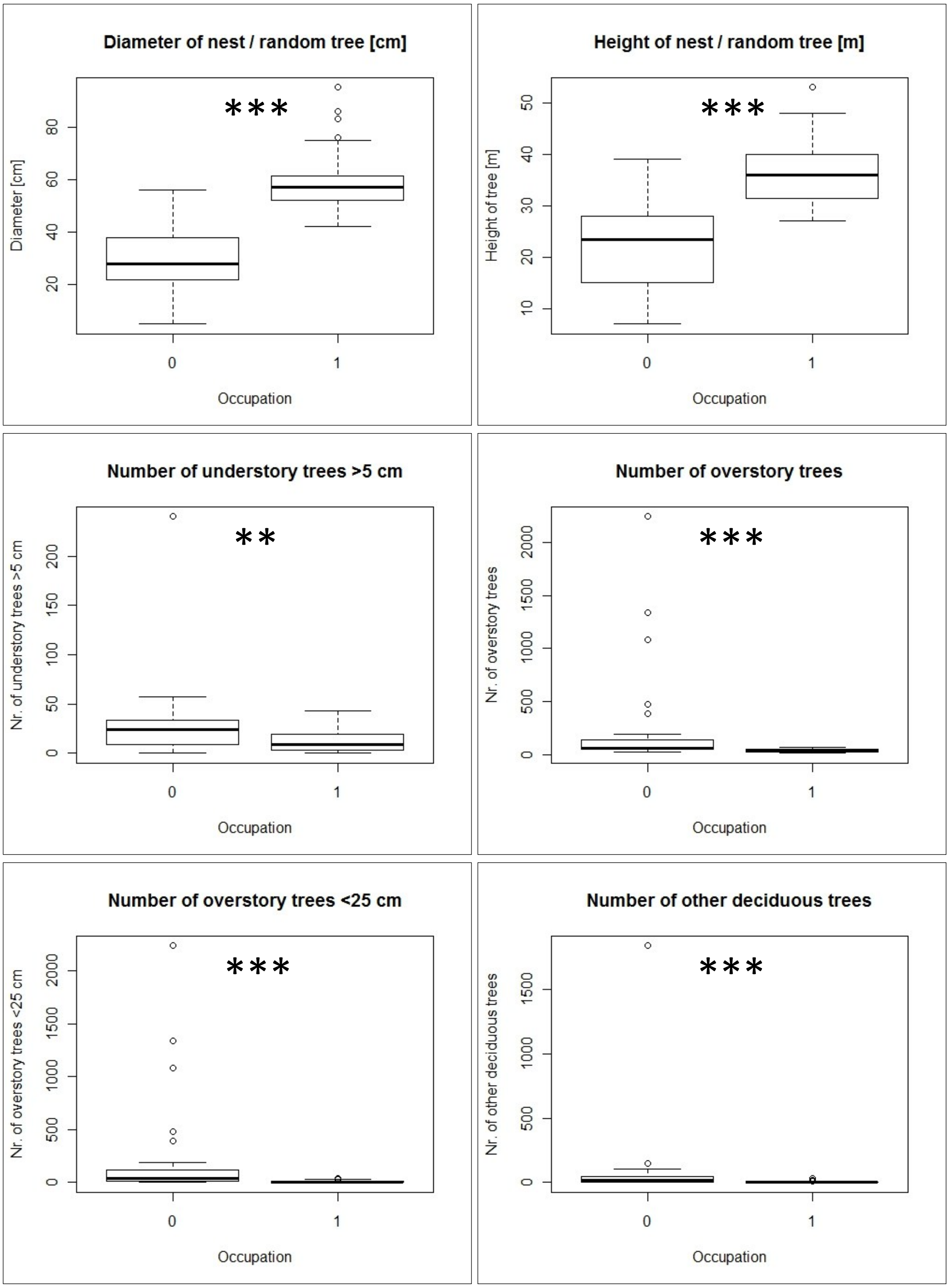

Figure 20: Boxplots of habitat variables showing significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. * = p < 0.05; ** = p < 0.01; *** = p < 0.001. 0 = random plots; 1 = nest sites; [cm] = centimetres; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

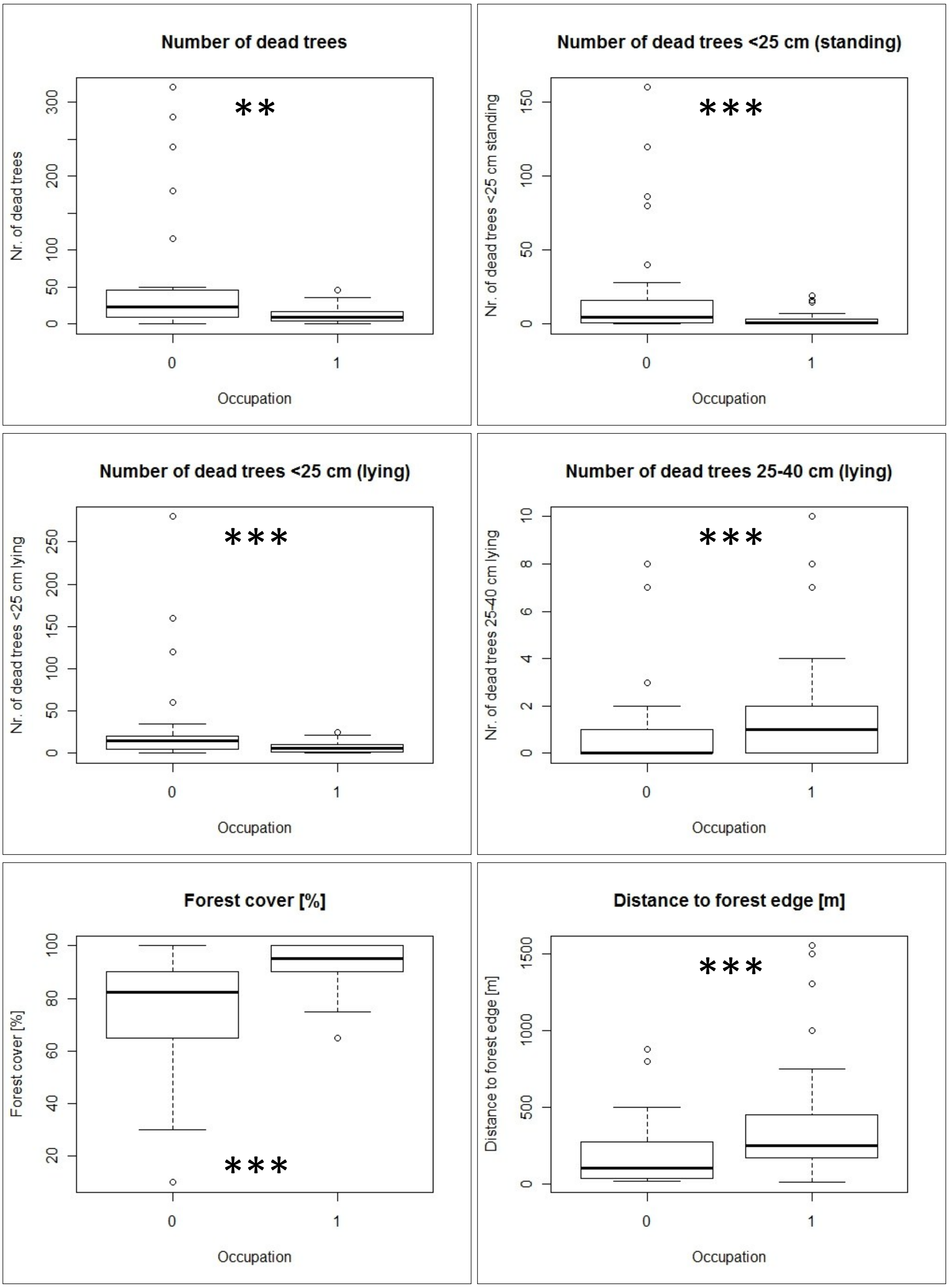

Figure 21: Boxplots of habitat variables showing significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$. 0 = random plots; 1 = nest sites; [%] = per cent; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

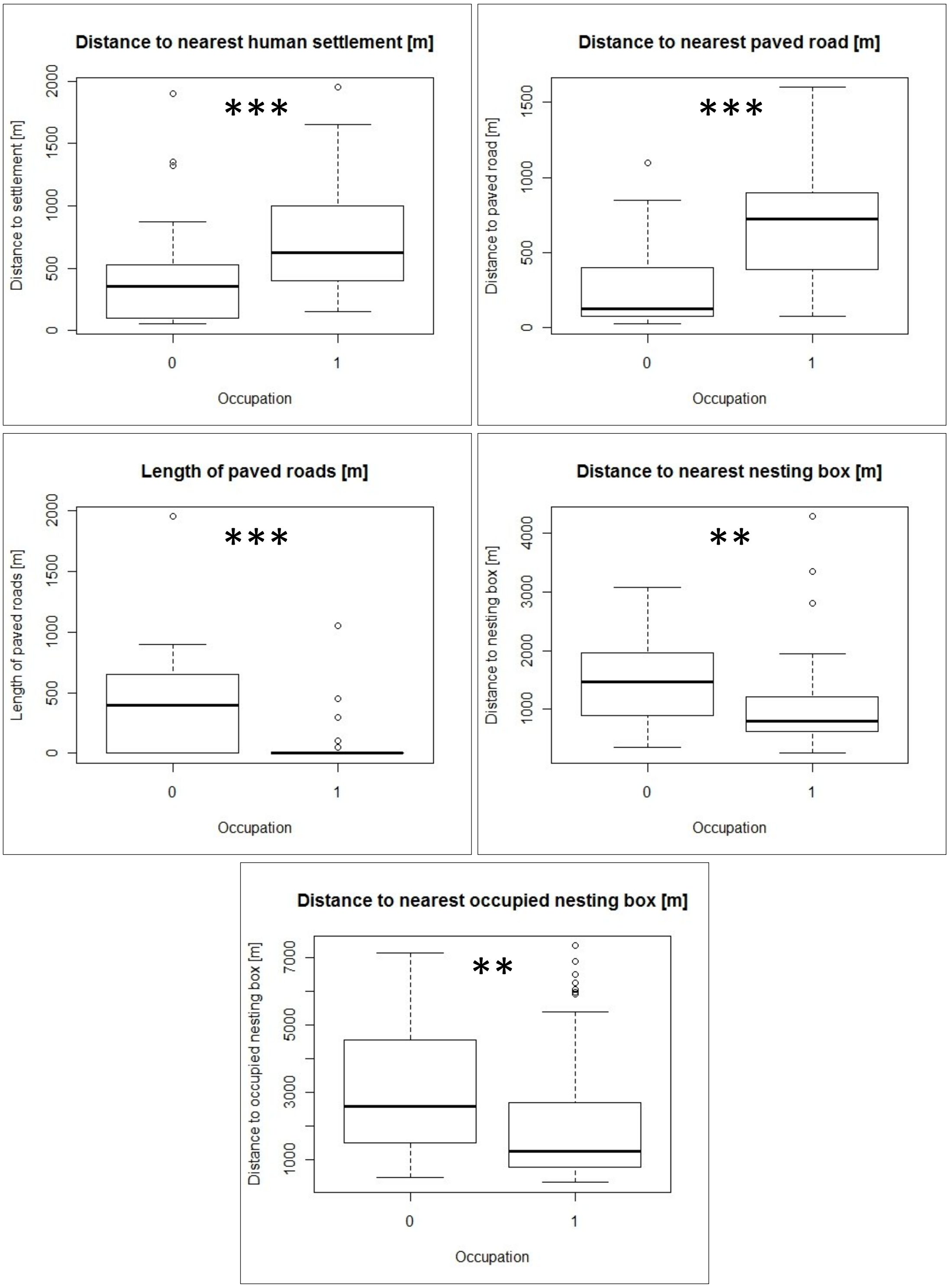

Figure 22: Boxplots of habitat variables showing significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. * = p < 0.05; ** = p < 0.01; *** = p < 0.001. 0 = random plots; 1 = nest sites; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

Results of PCA and LDA including comparisons of occupied and not occupied nest sites with random plots are shown and explained in chapter 3.2.1 (p. 36).

3.3 Prey abundance

3.3.1 Rodents

Altogether, three rodent species were trapped: Bank Vole *Chletrionomys glareolus*, Yellow-necked Mouse *Apodemus flavicollis*, and Wood Mouse *Apodemus sylvaticus*. Total numbers and morphological measurements of them are shown in Table 15. The Bank Vole clearly has the shortest ears, feet and tail, which can also be deducted from the large body length to tail length index. The Yellow-necked Mouse is the largest of the three species with the highest mean weight, and largest feet, body and tail. The Wood Mouse fits in between the two other species regarding length of feet and tail, but has the smallest weight and body, and the longest ears.

Table 15: Numbers and morphological measurements of live-trapped rodents recorded during trapping sessions in 2011. Results are presented in each cell according to the following pattern: "mean ± SD (minimum – maximum)". [g] = grams, [mm] = millimetres.

	Bank Vole *Chletrionomys glareoulus* (Schreber, 1780)	Yellow-necked Mouse *Apodemus flavicollis* (Melchior, 1834)	Wood Mouse *Apodemus sylvaticus* (Linnaeus, 1758)
Total number trapped	12	7	6
Weight [g]	33.7 ± 5.0 (25.4 – 43.9)	37.4 ± 7.6 (30.2 – 52.3)	30.5 ± 4.8 (22.6 – 36.5)
Ear length [mm]	10.8 ± 1.3 (9.0 – 13.0)	13.1 ± 1.5 (12.0 – 15.0)	14.0 ± 1.1 (12.0 – 15.0)
Hind foot length [mm]	16.1 ± 1.0 (14.0 – 18.0)	23.4 ± 0.8 (22.0 – 24.0)	21.3 ± 0.5 (21.0 – 22.0)
Body length [mm]	95.3 ± 10.4 (76.0 – 112.0)	97.4 ± 8.5 (86.0 – 110.0)	88.5 ± 10.0 (72.0 – 102.0)
Tail length [mm]	44.8 ± 5.6 (33.0 – 51.0)	92.4 ± 10.0 (74.0 – 102.0)	85.5 ± 9.5 (72.0 – 99.0)
Index Body length : Tail length	2.17 ± 0.43 (1.64 – 3.15)	1.07 ± 0.20 (0.84 – 1.46)	1.04 ± 0.06 (0.93 – 1.11)

An upward trend ($r_S = 1$; $P < 0.3$) in the number of rodents trapped can be seen in Figure 23. During the first trapping session in March, only six rodents were trapped, during the second session the number had already increased to eight individuals, and in the last session in May, eleven rodents were registered.

This linear trend is not as clearly visible in the number of rodents per trapping unit (Figure 24): at locations M3 (mixed forest), M4 (European Beech with little undergrowth) and M6 (European Beech with thick undergrowth), an upward trend can be observed, but at location M1 (Oak), the increase from March to April is followed by a decrease from April to May. Locations M2 (European Beech without undergrowth) and M5 (Norway Spruce) neither show a trend because no rodents were trapped there at all.

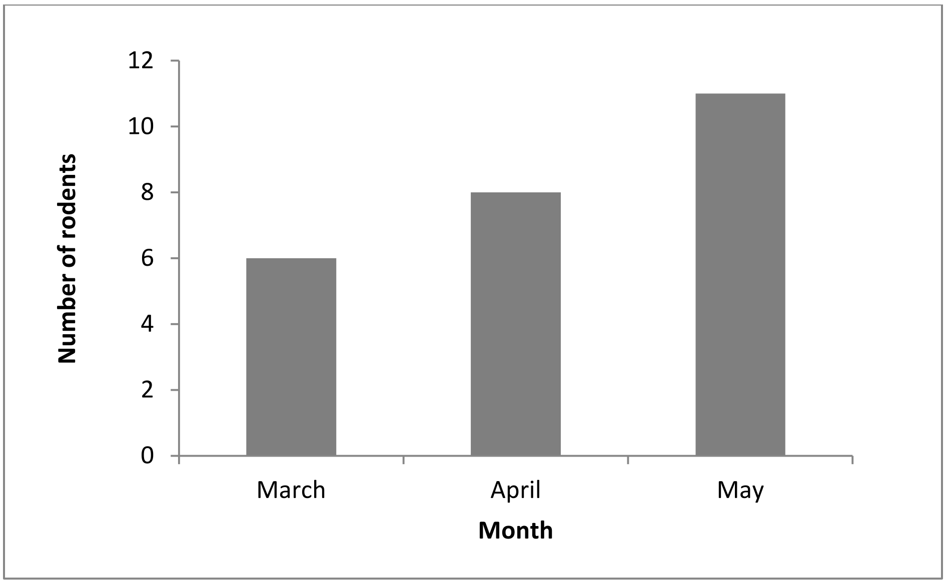

Figure 23: Total number of rodents trapped each month (r_S = 1; P< 0.3).

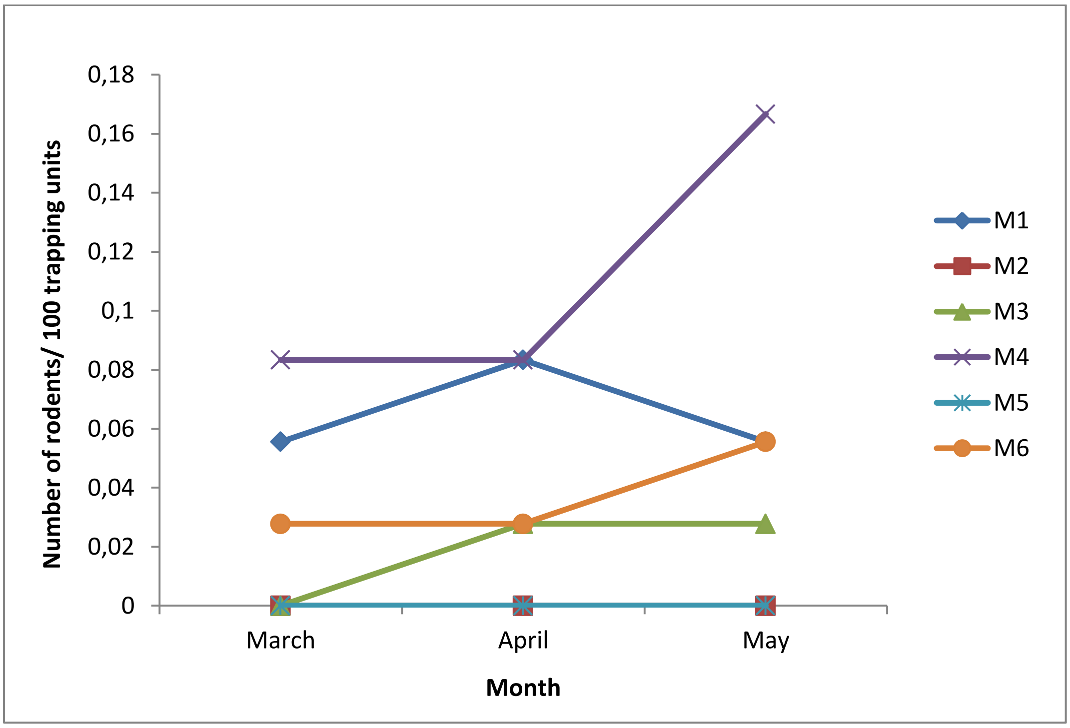

Figure 24: Overview of the number of rodents trapped each month at each trapping location (M1-M6) per 100 trapping units.

In contrast to the indistinct trend in the number of rodents per trapping units, a clear upward trend is discernible in the biomass of rodents caught each month at all trapping locations (Figure 25): the median increases gradually from March to May (15.4 g over 35.6 g to 47.7 g). This matches the increase of the total biomass of rodents at all six trapping locations summarized from March (200.1 g) over April (277.8 g) to May (373.1 g) (see Appendix 6-15).

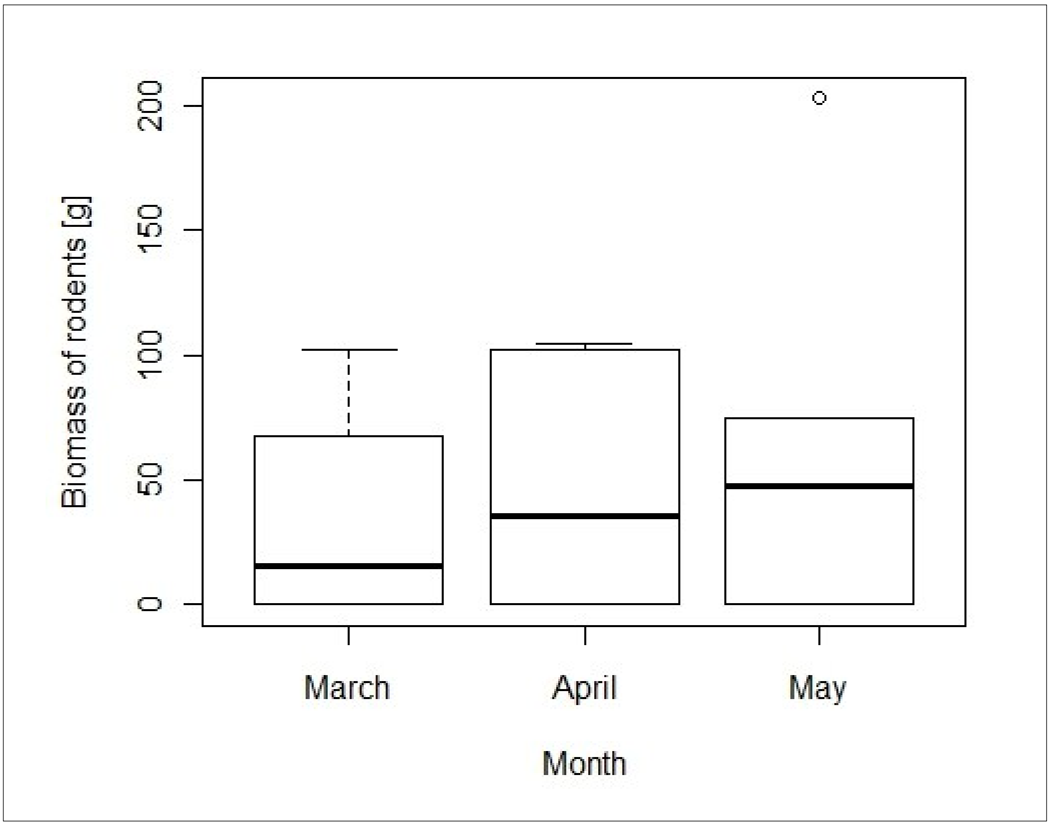

Figure 25: Biomass of rodents trapped each month at all six trapping locations. [g] = grams. Bold line = median; lower/ upper whisker = minimum/ maximum; circle = outlier.

3.3.2 Birds

A total of 1,568 individuals belonging to at least 39 species were recorded during the mapping period from March to May (Table 16). The most common species were the Common Chaffinch *Fringilla coelebs* (225 individuals) and the Great Tit *Parus major* (212 individuals), each contributing 14 % of the total of individuals of all species. Unspecified individuals (667 individuals) represented 15 % of all individuals. Although the Common Blackbird *Turdus merula* only contributed 6 % of the total number of individuals, it was most important regarding biomass (17 %), followed at a considerable distance by the Stock Dove *Columba oenas* with 5,500 grams (12 % of biomass) and the Common Chaffinch with 4,950 grams (10 % of biomass). The total number of birds recorded per month decreased slightly from March (557 individuals) over April (509 individuals) to May (502 individuals) (see Figure 26).

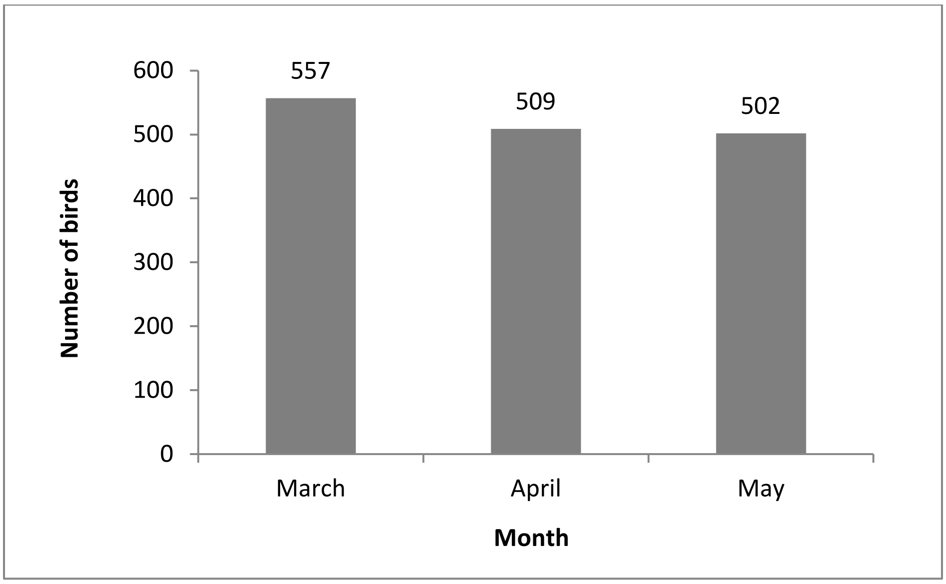

Figure 26: Total number of birds recorded each month (r_S = -1; *P*< 0.3).

Table 16: Diversity, total number and percentage of birds recorded each month, as well as average body weight of each species (according to GLUTZ VON BLOTZHEIM ET AL. 1994) and resulting biomass. Species are sorted by "∑ numbers" (descending). ∑ = sum; Ind. [%] = share of total number of individuals in %; % = per cent; Cum. = cumulative; [g] = grams.

Species	March	April	May	∑ numbers	Ind. [%]	Cum. ∑	Weight [g]	∑ biomass [g]
Unspecified	95	74	61	230	15	230	-	-
Common Chaffinch *Fringilla coelebs*	70	78	77	225	14	455	22	4950
Great Tit *Parus major*	73	66	73	212	14	667	19	4028
Eurasian Blackcap *Sylvia atricapilla*	19	50	52	121	8	788	18	2178
Common Blackbird *Turdus merula*	34	29	30	93	6	881	87	8091
Blue Tit *Parus caeruleus*	44	29	19	92	6	973	11	1012
Eurasian Nuthatch *Sitta europaea*	47	22	23	92	6	1065	20	1840
Common Chiffchaff *Phylloscopus collybita*	41	28	15	84	5	1149	8	672
European Robin *Erithacus rubecula*	22	12	32	66	4	1215	16	1056
Great Spotted Woodpecker *Dendrocopos major*	22	26	17	65	4	1280	73	4745
Song Thrush *Turdus philomelos*	18	12	16	46	3	1326	66	3036
Common Starling *Sturnus vulgaris*	7	12	10	29	2	1355	76	2204
Collared Flycatcher *Ficedula albicollis*	0	15	13	28	2	1383	14	392
Eurasian Wren *Troglodytes troglodytes*	9	5	13	27	2	1410	9	243
Stock Dove *Columba oenas*	4	11	5	20	1	1430	275	5500
Yellowhammer *Emberiza citrinella*	6	6	8	20	1	1450	29	580
Hawfinch *Coccothraustes coccothraustes*	10	0	3	13	1	1463	55	715
Common Firecrest *Regulus ignicapillus*	1	1	8	10	1	1473	5	50
Common Cuckoo *Cuculus canorus*	1	3	5	9	1	1482	107	963
Garden Warbler *Sylvia borin*	1	4	4	9	1	1491	19	171
European Goldfinch *Carduelis carduelis*	4	3	1	8	1	1499	16	128
Black Woodpecker *Dryocopus martius*	2	5	1	8	1	1507	300	2400
Marsh Tit *Parus palustris*	3	0	5	8	1	1515	11	88
Wood Warbler *Phylloscopus sibilatrix*	1	4	3	8	1	1523	9	72
Goldcrest *Regulus regulus*	5	0	3	8	1	1531	6	48
Eurasian Jay *Garrulus glandarius*	5	1	0	6	0	1537	156	936
Treecreepers *Certhia* spp.	1	3	1	5	0	1542	9	45
Middle Spotted Woodpecker *Dendrocopos medius*	2	1	1	4	0	1546	59	236
Woodpeckers *Picus spp*	4	0	0	4	0	1550	149	596
Eurasian Golden Oriole *Oriolus oriolus*	0	3	0	3	0	1553	70	210
Black Redstart *Phoenicurus ochruros*	2	0	1	3	0	1556	17	51
European Pied Flycatcher *Ficedula hypoleuca*	0	2	0	2	0	1558	12	24
Coal Tit *Parus ater*	2	0	0	2	0	1560	9	18
Dunnock *Prunella modularis*	1	1	0	2	0	1562	18	36
White Wagtail *Motacilla alba*	0	1	0	1	0	1563	21	21
Grey Wagtail *Motacilla cinerea*	1	0	0	1	0	1564	17	17
Spotted Flycatcher *Muscicapa striata*	0	1	0	1	0	1565	15	15
Willow Tit *Parus montanus*	0	1	0	1	0	1566	11	11
Eurasian Bullfinch *Pyrrhula pyrrhula*	0	0	1	1	0	1567	26	26
Eurasian Collared Dove *Streptopelia decaocto*	0	0	1	1	0	1568	200	200
∑	**557**	**509**	**502**	**1568**	**100**	**-**	**-**	**-**
∑ excluding unspecified	**462**	**435**	**441**	**1338**	**85**	**-**	**-**	**47604**

The 39 recorded small bird species were divided into 15 weight categories (Figure 27). Most species (21) belong to the lightest category 1 (1-19 g). Thirteen of the remaining species belong to categories 2 to 6 (20-119 g). Only two species, the Stock Dove *Columba oenas* (275 g) and the Black Woodpecker *Dryocopus martius* (300 g), belong to the heaviest categories 14 and 15, respectively. The gap between those two groups is covered by only three species in the categories 8 and 11 (Woodpeckers *Picus* spp., Eurasian Jay *Garrulus glandarius*, and Eurasian Collared Dove *Streptopelia decaocto*). The category "unspecified" was excluded from this analysis, as it was not possible to state the weight.

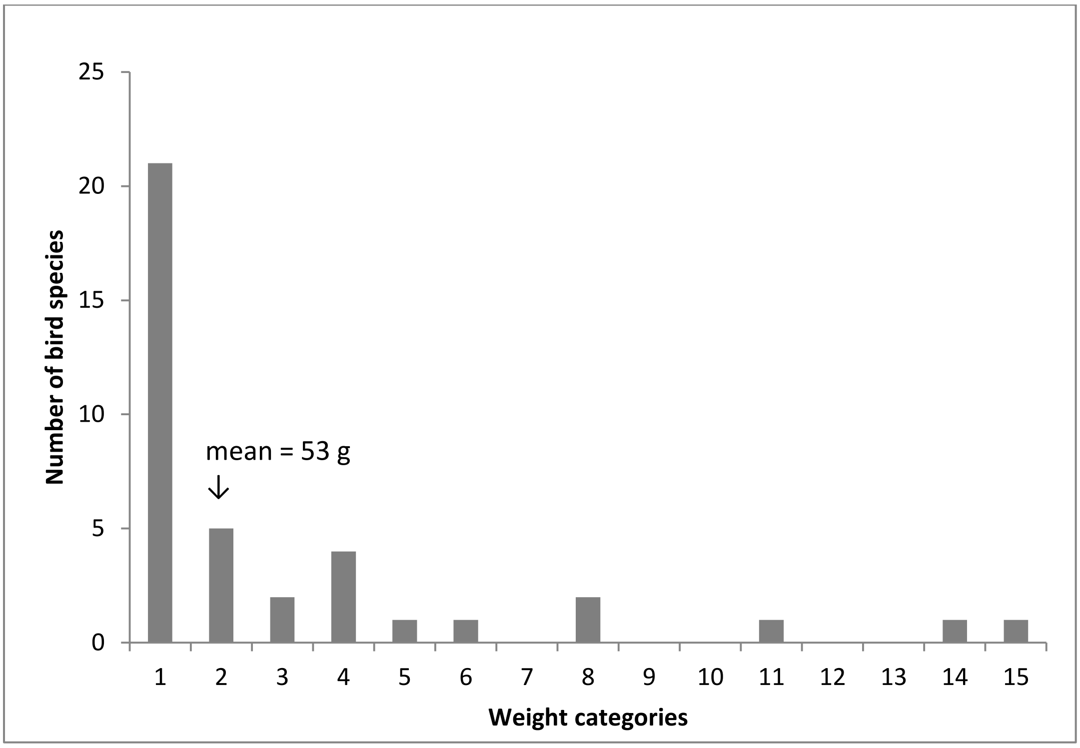

Figure 27: Number of bird species (n = 39) in weight categories 1-15. 1 = 1-19g; 2 = 20-39g; 3 = 40-59g; 4 = 60-79g; 5 = 80-99g; 6 = 100-119g; 7 = 120-139g; 8 = 140-159g; 9 = 160-179g; 10 = 180-199g; 11 = 200-219g; 12 = 220-239g; 13 = 240-259g; 14 = 260-279g; 15 = 280-300g. g = grams.

The diversification of individuals into 15 weight categories is similar to that of species above (compare Figure 28 below and Figure 27 above). Most individuals (including unspecified ones) are found in the lightest category 1 (928 individuals, 69 %), followed by categories 2, 4 and 5 (up to 99 g) consisting of 339, 143 and 93 individuals, respectively. The remaining 65 individuals are distributed to six categories (categories 3, 6, 8, 11, 14, and 15), with a maximum of 20 individuals in one group (category 14). The mean weight of a bird individual was 35.6 g (unspecified individuals excluded).

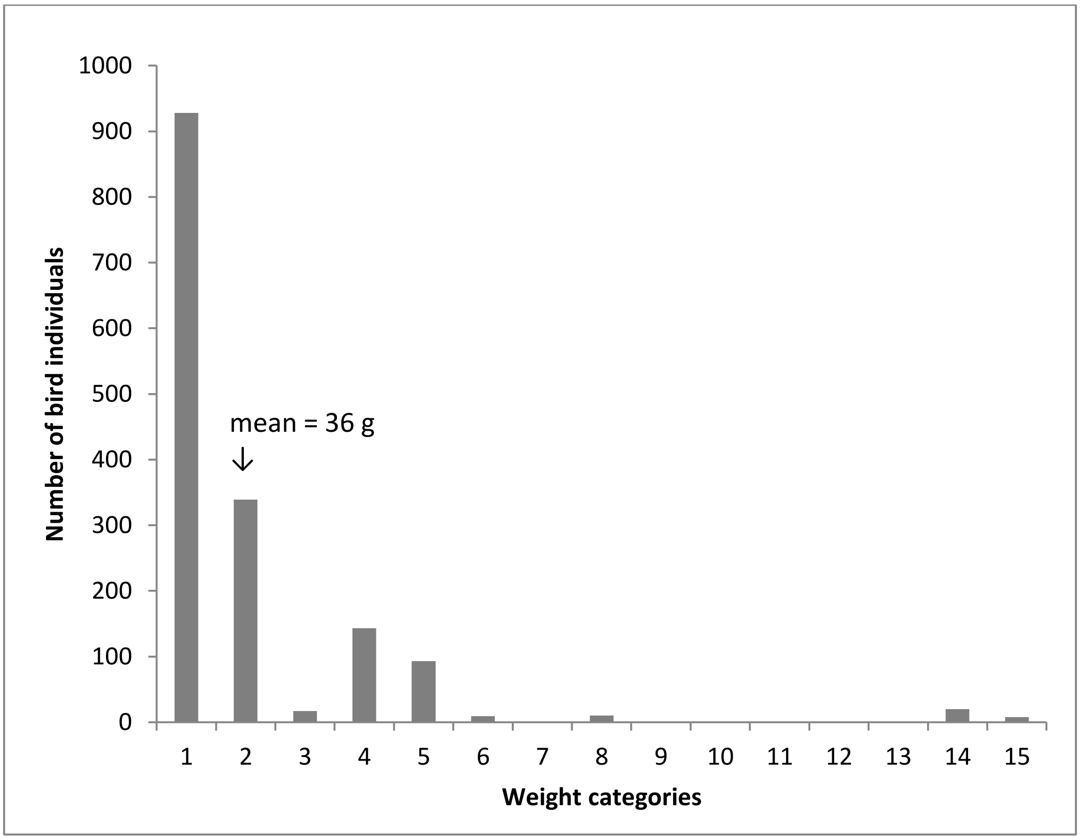

Figure 28: Number of bird individuals (n = 1,568) in weight categories 1-15. 1 = 1-19g; 2 = 20-39g; 3 = 40-59g; 4 = 60-79g; 5 = 80-99g; 6 = 100-119g; 7 = 120-139g; 8 = 140-159g; 9 = 160-179g; 10 = 180-199g; 11 = 200-219g; 12 = 220-239g; 13 = 240-259g; 14 = 260-279g; 15 = 280-300g. g = grams.

The slight downward trend in the number of birds from March to May is also obvious from Figure 29: the median of the number of individuals recorded at all six mapping locations decreases from 92.0 in March over 82.5 in April to 80.5 in May. Data are relatively scattered each month. The interquartile range spans approximately 30 individuals in March, 40 in April, and 25 in May, covering almost the whole range of data.

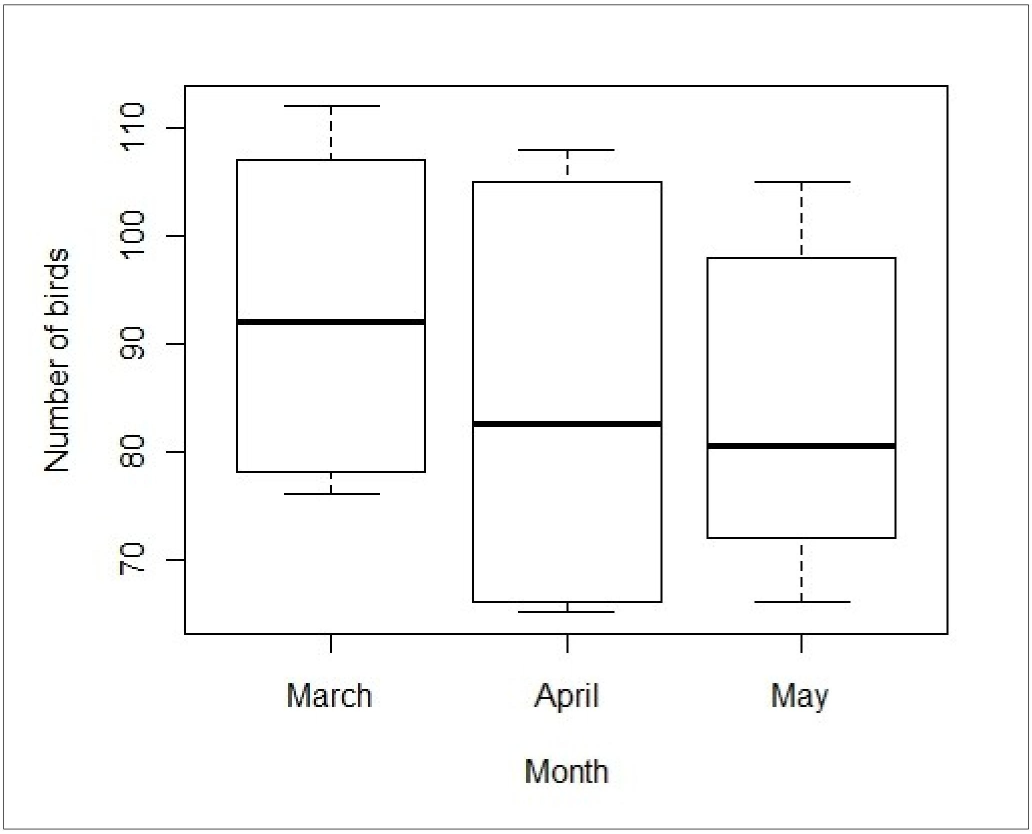

Figure 29: Total number of birds recorded each month at all six mapping locations. Bold line = median; lower/ upper whisker = minimum/ maximum.

When considering biomass instead of numbers, the category “unspecified” again has to be excluded (resulting in n = 1,338). In contrast to the slightly decreasing number of birds recorded, the median of biomass rises from March to April (2,314 g to 2,654 g), but then decreases again from April to May (2,338 g) (see Figure 30).

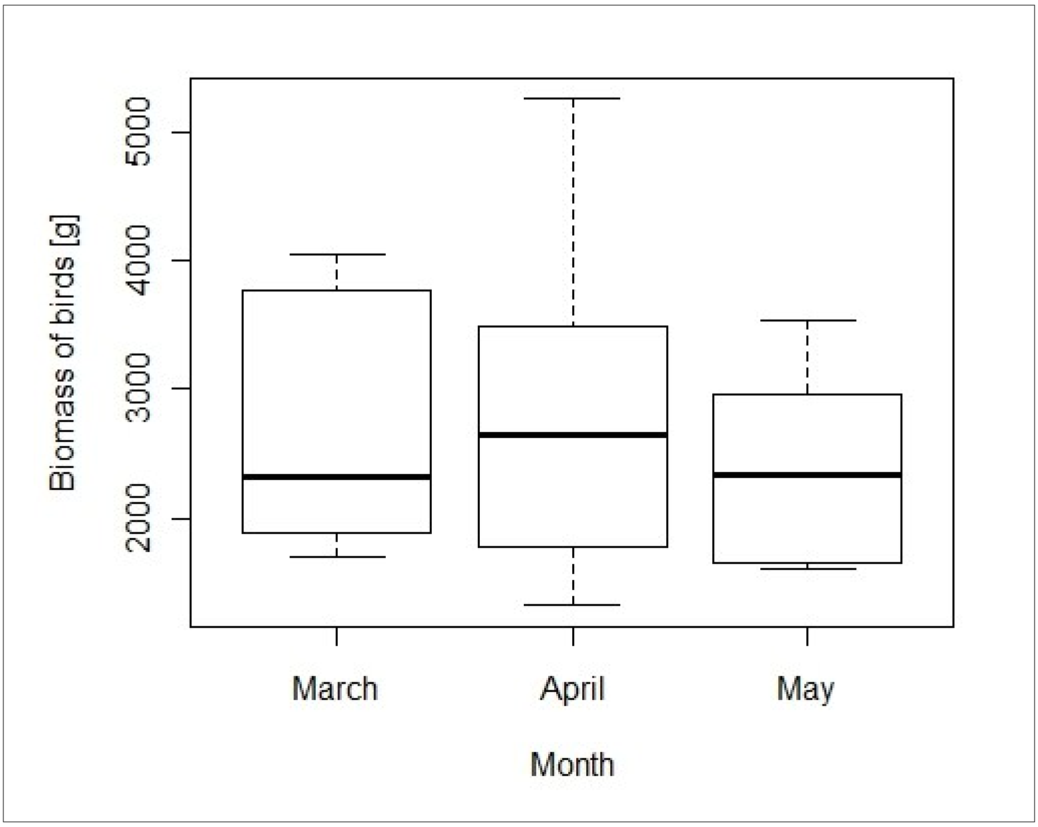

Figure 30: Biomass of birds recorded each month at all six mapping locations. [g] = grams. Bold line = median; lower/ upper whisker = minimum/ maximum.

3.3.3 Prey remains

A total of 75 prey remains were identified in the nine Tawny Owl nests controlled, almost all of them to species level. Dominant prey groups in 2011 were birds with 60.0 % and small mammals with 26.7 %. However, other vertebrates like reptiles (4.0 %), amphibians (5.3 %) and even one fish (1.3 %) were also taken. The number of recorded species was remarkably high with at least 29 species. Another interesting aspect was that 13 (28.9 %) of the 45 bird individuals were nestlings or fledglings, among them especially the more heavy bird species (Table 17).

Standardised food niche breadth amounting to 0.643 was relatively high. Weight variation of individual prey species was high in mammals (7-200 g) and birds (8-275 g). Maximum prey / predator relationship was 0.64 if mean weight of Tawny Owls was assumed to be 425 g (GLUTZ VON BLOTZHEIM ET AL. 1994), and geometric mean prey weight was relatively high with 65 g.

Table 17: Prey items of Tawny Owls by number and biomass identified in nine nesting boxes (NB) in the Biosphere Reserve Wienerwald in the year 2011. Underlined numbers mark nestlings or young individuals.

Species	NB 20	NB 28	NB 29	NB 31	NB 35	NB 36	NB 37	NB 117	NB 118	∑ numbers	Weight [g]	∑ Biomass [g]	∑ Biomass [%]
Mammals (Mammalia)													
Bi-coloured White-toothed Shrew *Crocidura leucodon*		1					1			**2**	12	24	1 %
Mole *Talpa europaea*		1					1			**2**	70	140	3 %
Brown Hare *Lepus europaeus*					<u>1</u>					**1**	200	200	5 %
Wood Mouse *Apodemus sylvaticus*									1	**1**	20	20	0 %
Yellow-necked Mouse *Apodemus flavicollis*		1					2			**3**	30	90	2 %
Harvest Mouse *Micromys minutus*							2			**2**	7	14	0 %
Common Vole *Microtus arvalis*							2			**2**	22	44	1 %
Bank Vole *Chletrionomys glareolus*				1	3					**4**	20	80	2 %
rodent unidentified		1			1	1				**3**	-	-	-
∑ Mammals (26.7 % of numbers)		**4**		**1**	**5**	**1**	**8**		**1**	**20**			**14 %**
Birds (Aves)													
Kestrel *Falco tinnunculus*									1	**1**	200	200	5 %
Great Spotted Woodpecker *Dendrocopos major*	1									**1**	73	73	2 %
Stock Dove *Columba oenas*			1		1					**2**	275	550	13 %
Eurasian Blackcap *Sylvia atricapilla*									1	**1**	18	18	0 %
Collard / Pied Flycatcher *Ficedula albicollis / hypoleuca*								1		**1**	14	14	0 %
European Robin *Erithacus rubecula*		1	1				1	1		**4**	16	64	1 %
Common Blackbird *Turdus merula*	1						1		<u>1</u>;3	**6**	87	522	12 %
Song Thrush *Turdus philomelos*	<u>1</u>;1	<u>1</u>	1			<u>1</u>	<u>1</u>	<u>1</u>	1	**8**	66	528	12 %
Mistle Thrush *Turdus viscivorus*	1				<u>1</u>				<u>1</u>	**3**	109	327	7 %
Great Tit *Parus major*	1	2						1		**4**	19	76	2 %
Blue Tit *Parus caeruleus*	1									**1**	11	11	0 %
Treecreepers *Certhia* spp.		1								**1**	9	9	0 %
Common Chiffchaff / Willow Warbler *Phylloscopus collybita / trochilus*									1	**1**	8	8	0 %
Hawfinch *Coccothraustes coccothraustes*	1					1				**2**	55	110	3 %
European Goldfinch *Carduelis carduelis*	1									**1**	16	16	0 %
Common Chaffinch *Fringila coelebs*	1									**1**	22	22	1 %
Eurasian Jay *Garrulus glandarius*					<u>3</u>		<u>1</u>	1		**5**	156	780	18 %

Table 17 - CONTINUED: Prey items of Tawny Owls by number and biomass identified in nine nesting boxes (NB) in the Biosphere Reserve Wienerwald in the year 2011. Underlined numbers mark nestlings or young individuals.

Species	NB 20	NB 28	NB 29	NB 31	NB 35	NB 36	NB 37	NB 117	NB 118	∑ numbers	Weight [g]	∑ Biomass [g]	∑ Biomass [%]
small bird unidentified		1	1							**2**	-	-	-
∑ Birds (60.0 % of numbers)	**10**	**6**	**4**		**5**	**2**	**4**	**5**	**9**	**45**			**76 %**
Reptiles (Reptilia)													
Slow-worm *Anguis fragilis*		1				1	1			**3**	100	300	7 %
∑ Reptiles (4.0 % of numbers)		**1**				**1**	**1**			**3**			**7 %**
Amphibians (Amphibia)													
Common Frog *Rana temporaria*		1					3			**4**	36	144	3 %
∑ Amphibians (5.3 % of numbers)		**1**					**3**			**4**			**3 %**
Fishes (Pisces)													
unidentified species		1								1	-	-	-
∑ Fishes (1.3 % of numbers)		**1**								**1**			-
Insects, Beetles (Coleoptera)													
Carabidae							2			**2**	-	-	-
∑ Beetles (2.7 % of numbers)							**2**			**2**			-
∑ numbers of all specimens	**10**	**13**	**4**	**1**	**10**	**4**	**18**	**5**	**10**	**75**		**4384**	**100%**

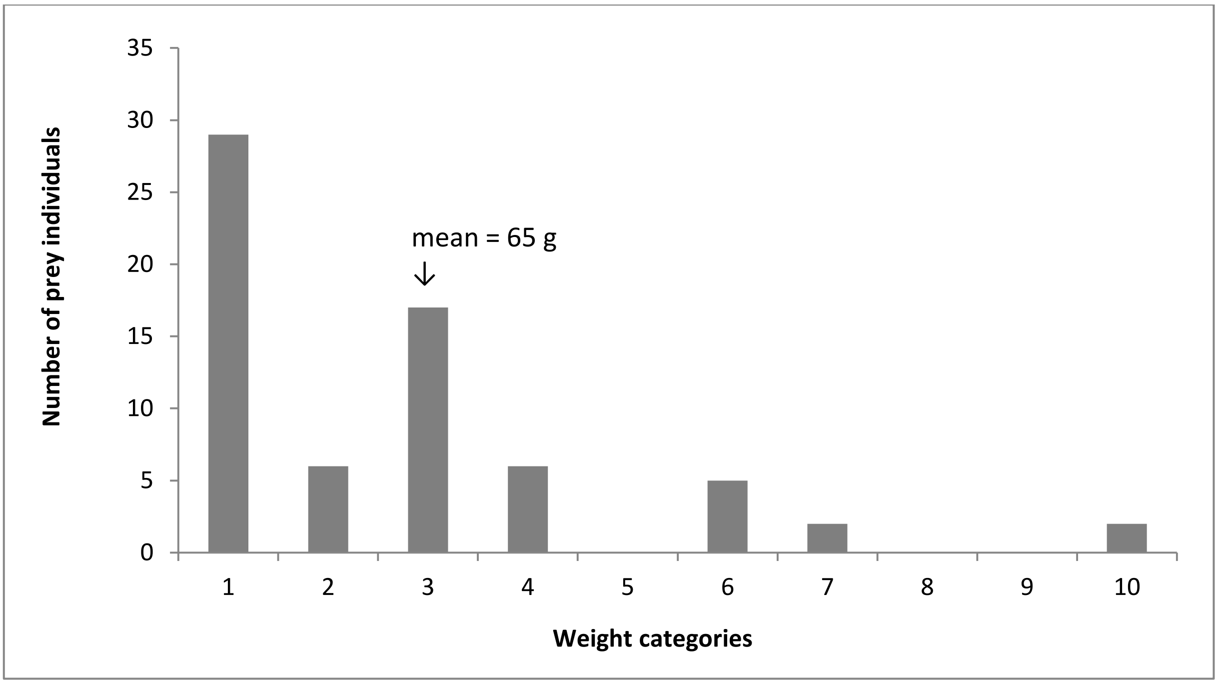

Figure 31: Number of identified prey individuals (n = 67) in weight categories 1-10. 1 = 1-30g; 2 = 31-60 g; 3 = 61-90 g; 4 = 91-120 g; 5 = 121-150 g; 6 = 151-180 g; 7 = 181-210 g; 8 = 211-240 g; 9 = 241-270 g; 10 = 271-300g. g = grams.

All recorded prey individuals (except unidentified individuals) were divided into ten weight categories (Figure 31). Most individuals weighed 30 g or less, but there were also many individuals weighing between 61 and 90 g. Only seven individuals had a weight exceeding 150 g and were found in categories 6, 7 and 10.

Interestingly, two Eurasian Jay *Garrulus glandarius* (Linnaeus, 1758) nestlings were found in one nesting box (NB 35). As they were untouched, they were returned to the box (see Figure 32). These two items were also included in the prey list.

Figure 32: Two Eurasian Jay nestlings found in a nesting box occupied by Tawny Owls. They were returned after nest control (18 May 2011). © 2011 Julia Gstir.

4 Discussion

4.1 Breeding period and breeding success

Breeding time in Tawny Owls is dependent on various factors like altitude, sea level, food abundance and length of winter period (MELDE 1989; GLUTZ VON BLOTZHEIM ET AL. 1994; MEBS & SCHERZINGER 2000; SASVÁRI & HEGYI 2011). Time and duration of the different phases of the breeding period of Tawny Owls in the Vienna Woods lay within the large variations mentioned by other authors. Egg laying may commence as early as 1 February, followed by the nestling period beginning in the middle of March, and the fledgling period from 1 May until 30 June (ZALEWSKI 1994), but fledging may also last as long as middle of August if incubation starts as late as April (SUNDE ET AL. 2001). Other studies reported the beginning of egg laying for March (MIKKOLA 1983; KÖNIG ET AL. 1999) and of fledging for May (OVERSKAUG ET AL. 1999), which was also observed in the present study.

The breeding success observed amounted to only 1.8 young per inspected successful breeding pair. Tawny Owls usually have a breeding success of 2 – 3 young per successful breeding pair (WENDLAND 1984; AVOTINŠ & KEMLERS 1993; PLESNÍK & DUSÍK 1994; FABIAN & SCHMIKAT 2009). The survival of young may have been reduced due to the small number of rodents in the study area in spring 2011, which was the consequence of two years (2009 and 2010) of very low beech seed harvest in the study area (see chapter 4.4, p. 69). However, PETTY (1999) and also SOLONEN & KARHUNEN (2002) showed that the number of voles has a minor effect on breeding success in Tawny Owls because they respond rather with a change in diet than with a change in reproduction. Their flexible feeding habits allow them to switch to alternative prey (WENDLAND 1984; JĘDRZEJEWSKI ET AL. 1994; TISHECHKIN 1997; PETTY 1999; SOLONEN & KARHUNEN 2002; BALČIAUSKIENĖ ET AL 2006). Only the number of breeding attempts depends on the number of voles in spring (SOLONEN & KARHUNEN 2002).

The number of breeding attempts could not be determined in this study because neither was the area searched for breeding attempts outside nesting boxes (e.g. in natural cavities), nor were all nesting boxes occupied in the egg laying period examined again during the nestling period to see how many breeding attempts were successful and how many were not.

4.2 Habitat differences between occupied and not occupied nest sites

The Tawny Owl is known as a widespread and probably most adaptable of all European owl species. Therefore, it can be predicted that it is a species also flexible regarding habitat selection. This was confirmed to a certain extent in the present study. However, it was also shown that a certain minimum of requirements have to be fulfilled regarding habitat composition, otherwise a site does not hold any attractions for Tawny Owls to use it as nest site.

The expectation was that Tawny Owls prefer hall-like forests with low tree numbers and thus thin tree densities to be able to fly unimpaired between the trees and to access their rodent prey on the floor (SOUTHERN & LOWE 1968; PETTY 1989). But obviously, they also need a certain amount of trees for cover, for example to hide from mobbing birds or predators during the day (SUNDE ET AL. 2003; HENDRICHSEN ET AL. 2006). Thinner, younger trees may also provide branches at lower levels which could be used as perches when Tawny Owls are listening for their rodent prey (SOUTHERN 1970; HIRONS 1985; GALEOTTI 2001).

Another expectation was that in 2011, the proportion of nesting boxes in habitats with a higher proportion of coniferous trees being occupied would be higher than usual in comparison to nesting boxes in purely deciduous habitats because of the past two successive years (2009 and 2010) in which beech trees failed to produce seeds. Bank Voles, Yellow-necked Mice and Wood Mice are dependent on beechnuts and acorns to feed on and store (JENRICH ET AL. 2010a). Therefore, their numbers are usually higher in deciduous than in coniferous or mixed woods, but were expected to be lower in 2011 due to the failure of beech trees to produce seeds in the past years. However, the highest numbers of rodents recorded in this study were still found in deciduous forests, fewer rodents were trapped in mixed forests, and none in pure coniferous forests. Not taken into consideration in these results is that abundance is not necessarily equal to availability: the highest numbers of rodents were detected in a beech forest with undergrowth which may effectively protect rodents by preventing Tawny Owls from seizing them. At the trapping location in a beech forest without undergrowth, where Tawny Owls could seize their prey without hindrance, no rodents were trapped in 2011. It is common that pairs simply do not breed in years that fail to provide the necessary preconditions (HIRONS 1985; SOLONEN & KARHUNEN 2002; KARELL ET AL. 2009), so probably fewer pairs than usual bred in nesting boxes in purely deciduous forests in the study area in 2011, while the number of pairs breeding in nest sites with a higher proportion of coniferous trees sank less in comparison. Tawny Owl pairs usually stay in the same territory for all their lives, and few changes occur in the distribution of neighbouring territories between years (MIKKOLA 1983; HIRONS 1985; HARDY 1992; SUNDE & BOLSTAD 2004). SUNDE ET AL. (2001) also observed that Tawny Owls in Norway in winter prefer habitats which also contain coniferous trees because deciduous trees lose their leaves in autumn and deprive the owls of cover.

It came as a surprise that the numbers of dead trees with large diameters were higher at not occupied nest sites than at occupied nest sites, since rodents need habitats containing dead trees for cover (JENRICH ET AL. 2010a), and I assumed that Tawny Owls would therefore also prefer these habitat types, were numbers of rodents would be higher. However, numbers of dead trees were generally very low, so it might be possible that differences are negligible from the point of view of rodents and Tawny Owls. Similarly, it is likely that the distance to the nearest nesting box is smaller in occupied than in not occupied nest sites just by chance because nesting boxes are not distributed evenly over the study area.

Although group separation was clearly discernible in the LDA, a strong overlap between occupied and not occupied nest sites resulted in the PCA. Occupied nest sites occurred in only slightly more limited conditions than not occupied nest sites. The reason of the weak differentiation might be that PC1 and PC2 together explain only about one third of variance, which probably is not sufficient for a clear outcome. However, habitat variables most important for PC1 (Nrost, Nrost25, Nrdead, Nrdead25l) confirmed the results of the other analyses discussed above. Habitat variables most important for PC2 are moderate forest cover and a large distance to the nearest paved road.

In the remaining habitat variables studied, no significant differences between occupied and not occupied nest sites were detected, which underlines the fact that Tawny Owls as a generalist species are very flexible in the habitat they use and may even populate urban areas (RANAZZI ET AL. 2000; FABIAN & SCHIMKAT 2009). According to SÁNCHEZ-ZAPATA & CALVO (1999), who studied Tawny Owls in Spain, they may even nest in rocky holes and use nearby mature pine stands for perching and hunting. However, woodland is their preferred habitat (MIKKOLA 1983), and it is also essential if they live in larger territories including only small isolated woodland patches: even in these fragmented habitats, Tawny Owls mostly use wooded areas, which they need to roost, nest and hunt, and they have to increase their territory size to include sufficient wooded areas (REDPATH 1995). SALVATI ET AL. (2002) furthermore confirmed that the proportion of wooded area in a Tawny Owl territory is influenced by its quality: large amounts of wooded area were found in territories with low prey abundance, whereas small amounts of wooded area were found in territories with high prey abundance. Similar results were found by HIRONS (1985) in the United Kingdom. And SUNDE ET AL. (2001) reported that Tawny Owl territories are larger in Norway at the northern edge of their range because of extreme conditions.

The Vienna Woods consisting mostly of deciduous forests interrupted by a mosaic of meadows (LAMMERHUBER ET AL. 2010) seem to be a mostly suitable habitat so that only few differences between occupied and not occupied nest sites could be found in this study. An explanation for empty nesting boxes might be that they are situated within territories of Tawny Owl pairs which breed in a natural cavity and therefore were not registered in this study, or in a different nesting box nearby. It would be possible that even more Tawny Owl pairs will change from natural nest sites to nesting boxes in the future since many Tawny Owls seem to prefer them to possibly suboptimal natural nest sites (PETTY 1992; AVOTINŠ 2004).

Furthermore, the variation within the 60 nest sites in general was rather small in the first place because all nesting boxes were installed for the Ural Owl reintroduction project according to guidelines imposed by the demands of the Ural Owl on its habitat. This large owl needs forests to breed, and as an almost exclusive rodent hunter is especially adapted to rodent cycles, which are more pronounced in hall-like deciduous forests than for example in mixed forests. Therefore, hall-like beech forests with almost no undergrowth represent an ideal habitat because they provide suitable breeding sites and prey, especially in mast years. Also important is a mosaic of meadows and clearings in the surrounding area to hunt for small mammals (ZINK & PROBST 2009).

However, as several significant differences between occupied and not occupied nesting boxes were discovered in the course of this study, the null hypothesis stating that Tawny Owls do not choose their breeding sites based on the habitat variables under investigation was disproved.

4.3 Habitat differences between nest sites and random plots

Many significant differences between nest sites and random plots were discovered. This is also visible from the LDA, where only low values in LD1 were necessary to clearly show the group separation between nest sites and random plots. The main reason is that all nest sites at which nesting boxes were fixed were chosen according to guidelines of the Ural Owl reintroduction project mentioned above (ZINK & PROBST 2009), which directly or indirectly influenced the recorded habitat variables.

4.4 Relationship between prey abundance and prey choice

Prey availability is a key factor for the occurrence of a predator like the Tawny Owl, but as an opportunistic species, it is able to change to alternative prey if the preferred prey is scarce. In large parts of its range, the Tawny Owl prefers rodents if they are available (SOUTHERN 1969; GLUTZ VON BLOTZHEIM ET AL. 1994; JĘDRZEJEWSKI 1996; AEBISCHER 2008).

Numbers of the three rodent species trapped in the BPWW in spring 2011 were low compared to other studies done in the vicinity of the study area (MITTER G. IN PREP.; SPITZENBERGER 2001). This was due to the low population density caused by two successive years (2009 and 2010) without beech seed harvests in the study area, and a rather low oak seed harvest in 2010 (LITSCHAUER, UNPUBLISHED DATA). Still, a significant ascending trend of numbers and biomass from March to May caused by progressive rodent reproduction beginning between February and March (JENRICH ET AL. 2010a) was discernible.

Small birds are the second most common prey in other areas mentioned by GLUTZ VON BLOTZHEIM ET AL. (1994). Birds are represented by more species than mammals, so they may form a more stable food base, but they are probably costlier to prey upon. Common Chaffinches and Great Tits were the bird species most common in numbers in the study area, while the Common Blackbird was most common regarding biomass. Most individuals and species weighed less than 30 g. In contrast to rodents, bird numbers decreased slightly from March to May, while biomass increased slightly and then decreased again. This downward trend can be explained by two factors: on the one hand, the numbers of migratory birds present (and some also singing) in the study area are higher in March than in April and May because these birds only stay for a short time; and on the other hand, the singing activity of birds staying in the study area drops from March to May because courtship and territorial disputes are less important and breeding business prevails, so they may be underrepresented later on.

The diet composition of Tawny Owls as revealed in this study differed from diets reported elsewhere. Only KIRK (1992) reported a similar distribution of biomass: the share of birds was as large as 77 %, while that of mammals was only 22 % and that of beetles 1 %. Contrary to this, KORPIMÄKI & NORRDAHL (1989) studied data from northern, western and central Europe and concluded that the diet of Tawny Owls during the breeding season consists to 66 % of mammals, 26 % of birds, 6 % of amphibians and 3 % of insects (in numbers). An even stronger disproportion in favour of mammal prey was found in the Italian Alps, where mammals contributed as much as 82 % to biomass, and birds and insects only 13 % and 5 % respectively (MARCHESI ET AL. 2006). Due to the low rodent abundance in the study area in 2011, the proportion of birds in the Tawny Owl diet (76 % of biomass), as well as mean prey weight (65 g) were relatively high. This means that the owls preferably preyed on heavier bird species, even though smaller species were more abundant. The standardised food niche breadth also was relatively high, meaning that they had a diet rich in species and used not only birds, but a variety of different species (e.g. slowworms) as alternative prey. This underlines that this owl species is an opportunistic predator which quickly reacts to the current prey situation (MIKKOLA 1983; WENDLAND 1984; PETTY 1989; KIRK 1992; PLESNÍK & DUSÍK 1994; BALČIAUSKIENĖ ET AL. 2006; MARCHESI ET AL. 2006).

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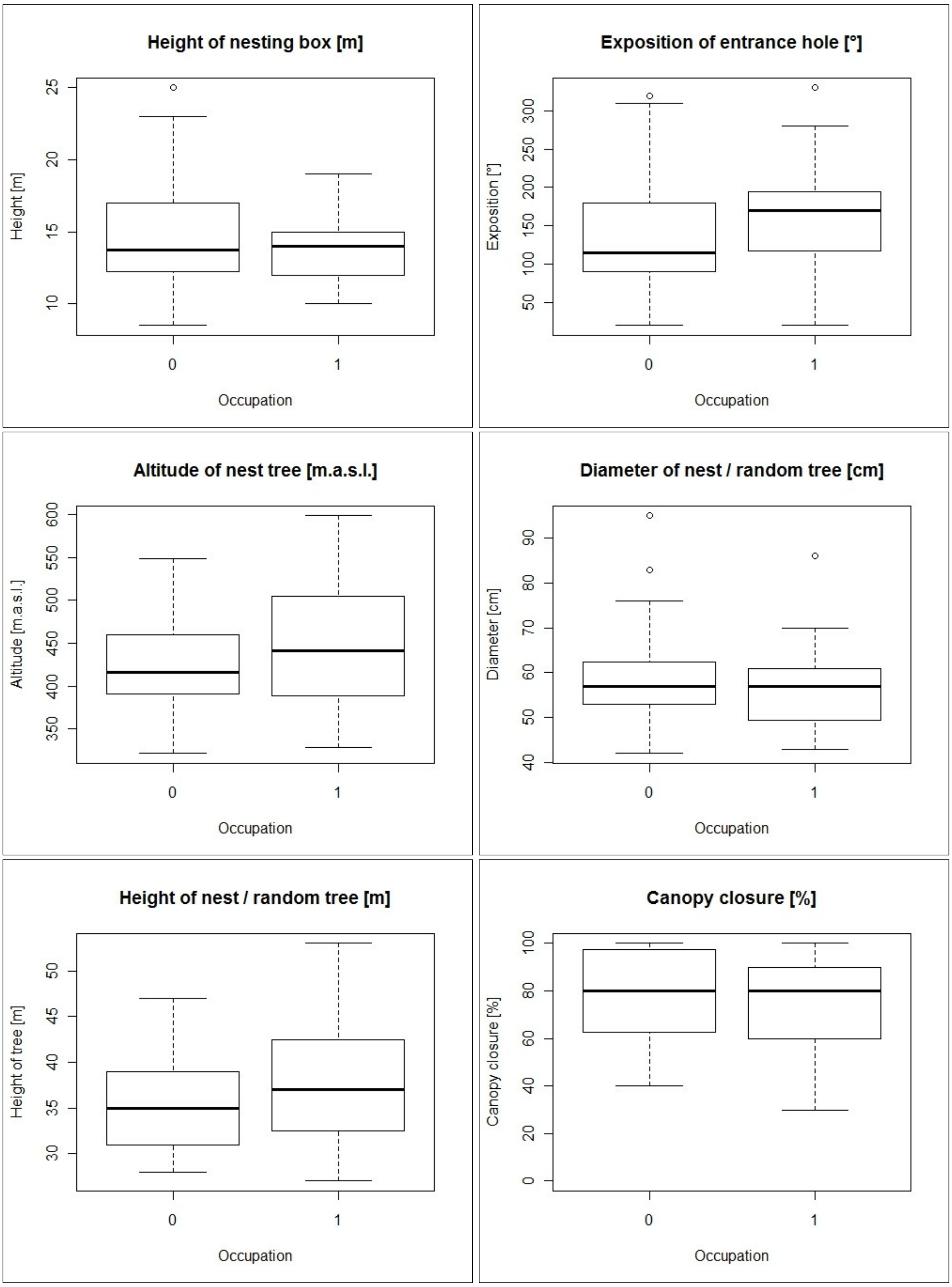
6 Appendix

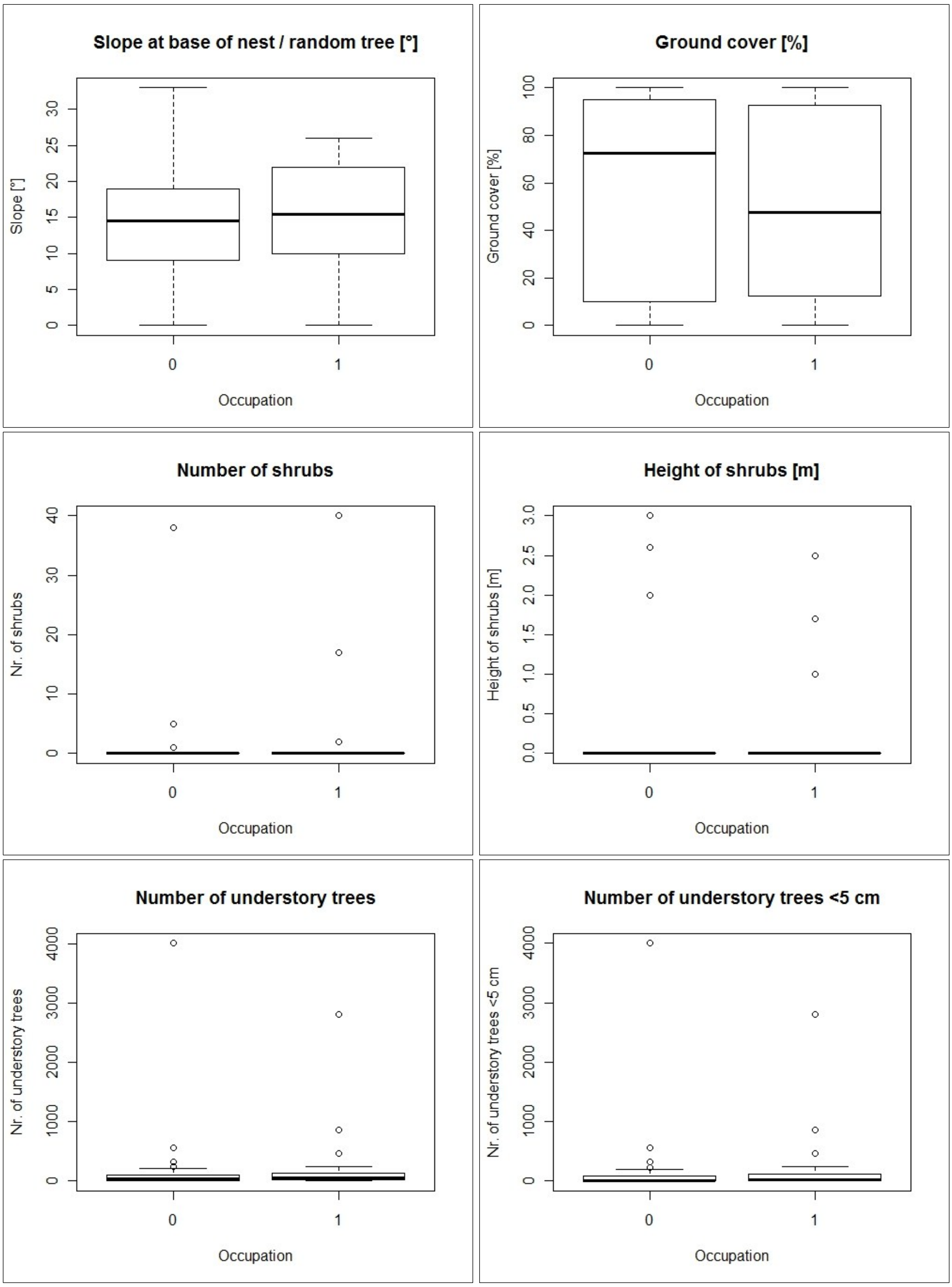
6.1 Habitat variables not significant in the analyses

6.1.1 Comparisons between occupied and not occupied nest sites

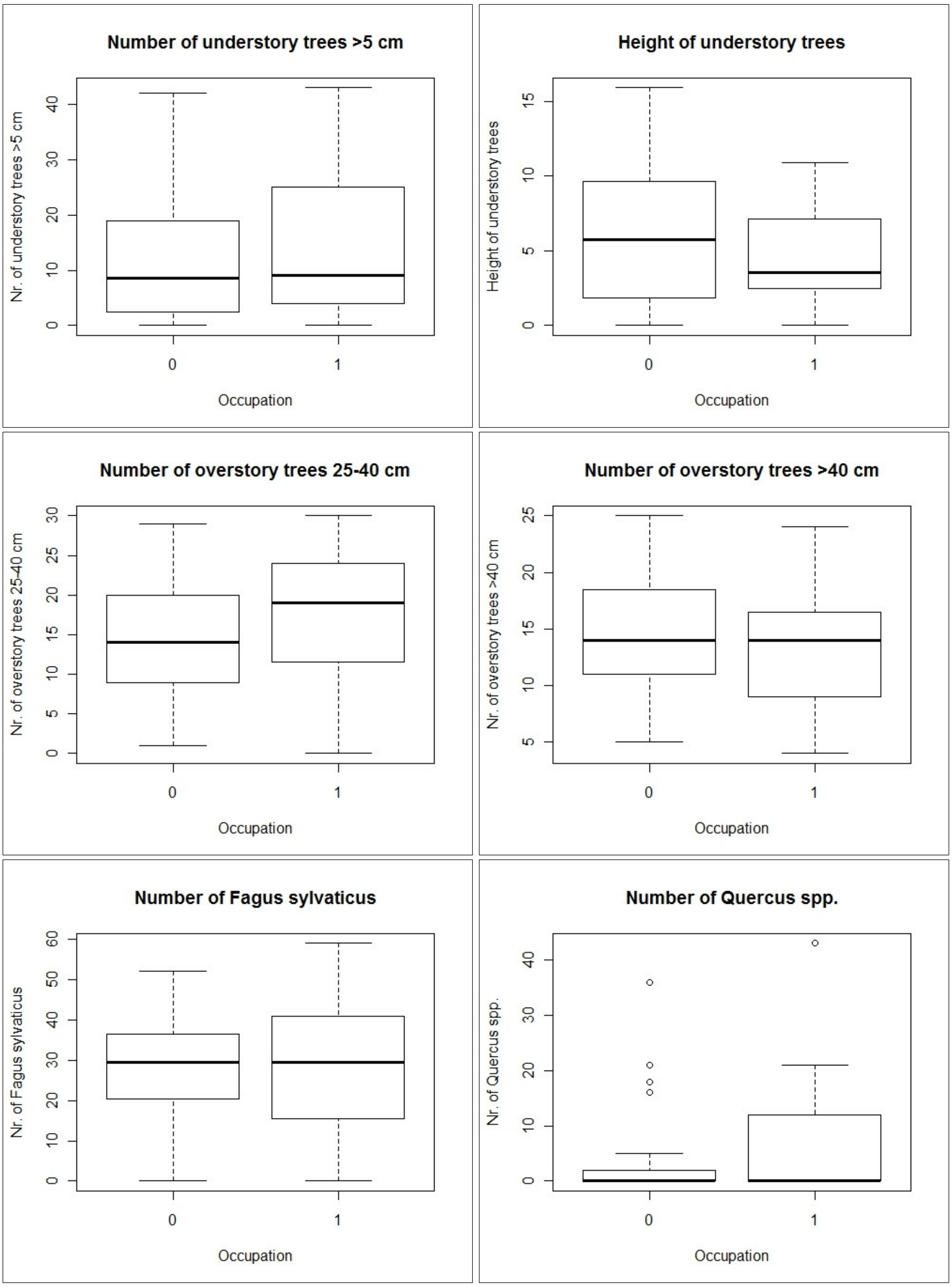
Appendix 6-1: Habitat variables not showing any significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = not occupied nest sites; 1 = occupied nest sites; [m] = metres; [°] = degrees; [m. a. s. l.] = metres above sea level; [cm] = centimetres; [%] = per cent. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.



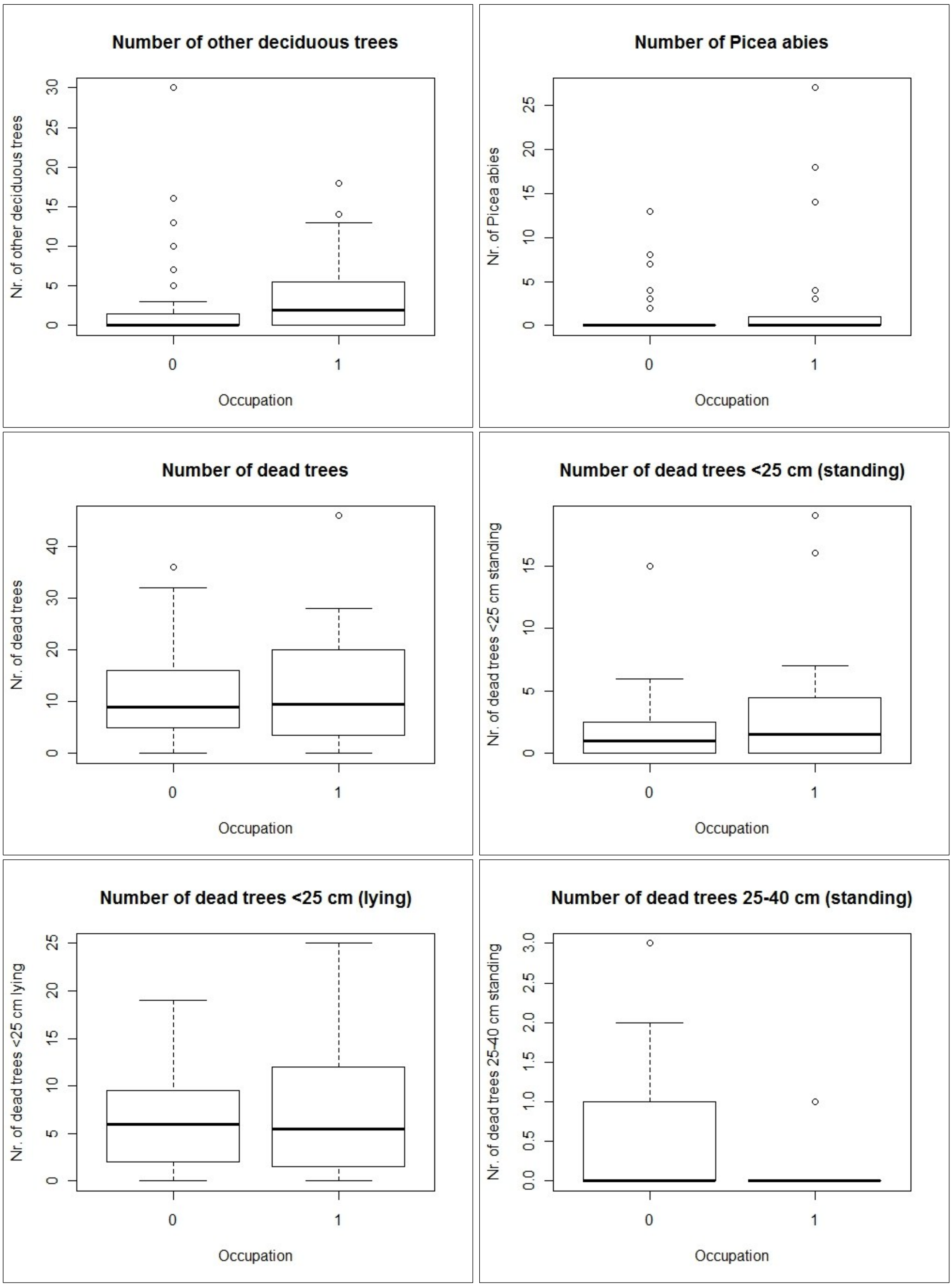
Appendix 6-2: Habitat variables not showing any significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = not occupied nest sites; 1 = occupied nest sites; [°] = degrees; [%] = per cent; [m] = metres; cm = centimetres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.



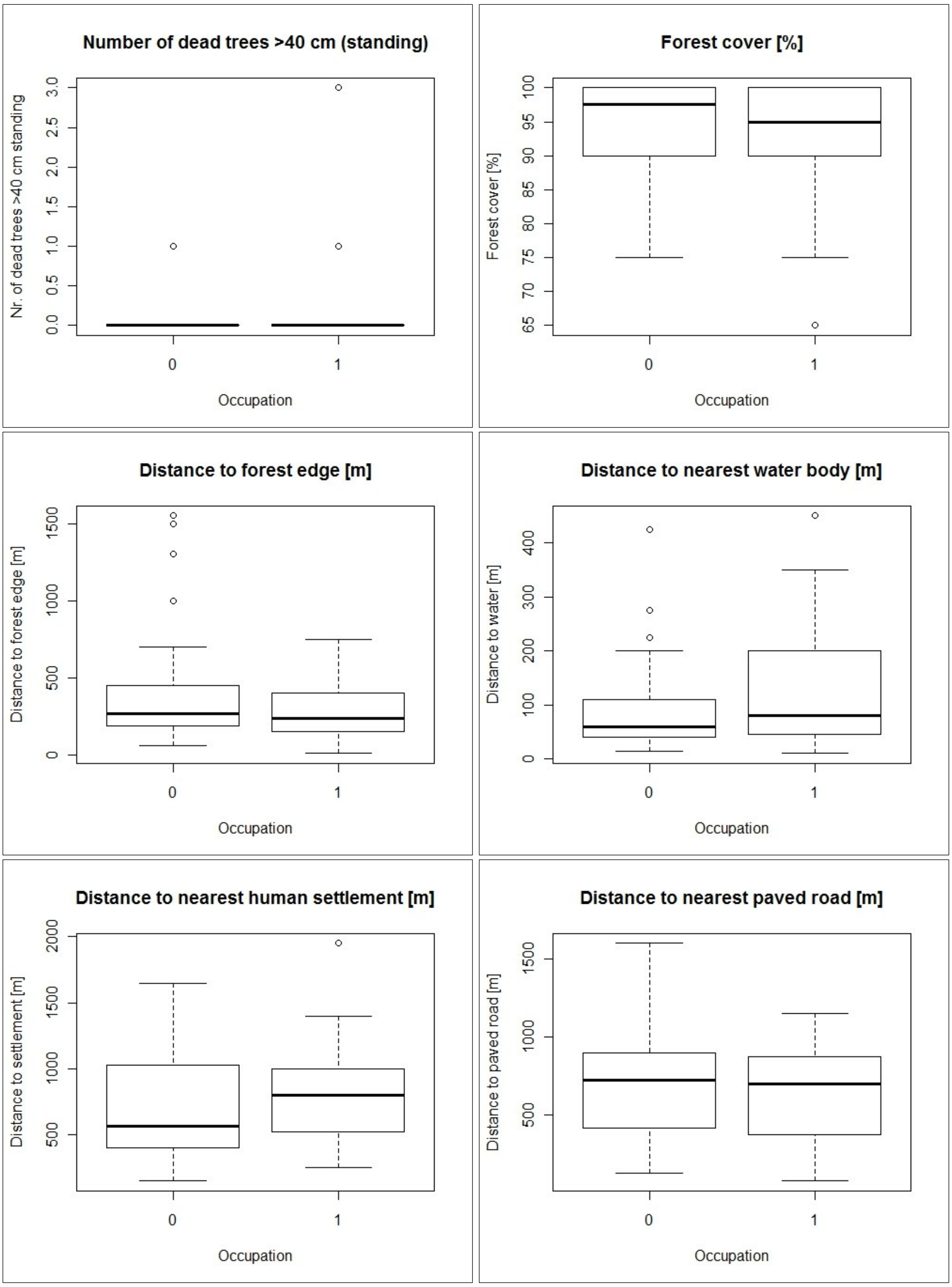
Appendix 6-3: Habitat variables not showing any significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = not occupied nest sites; 1 = occupied nest sites; cm = centimetres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.



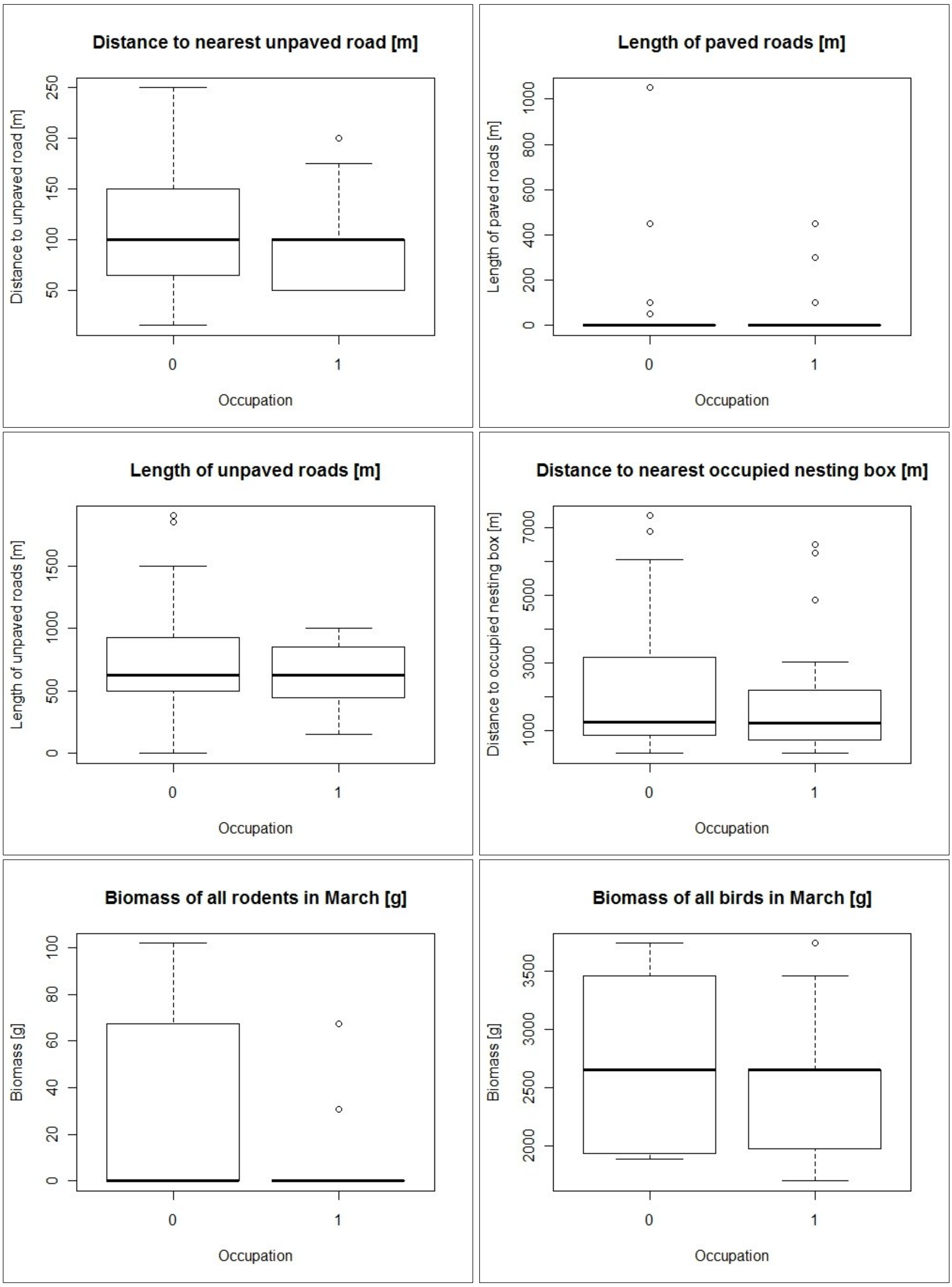
Appendix 6-4: Habitat variables not showing any significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = not occupied nest sites; 1 = occupied nest sites; cm = centimetres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.



Appendix 6-5: Habitat variables not showing any significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = not occupied nest sites; 1 = occupied nest sites; cm = centimetres; [%] = per cent; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

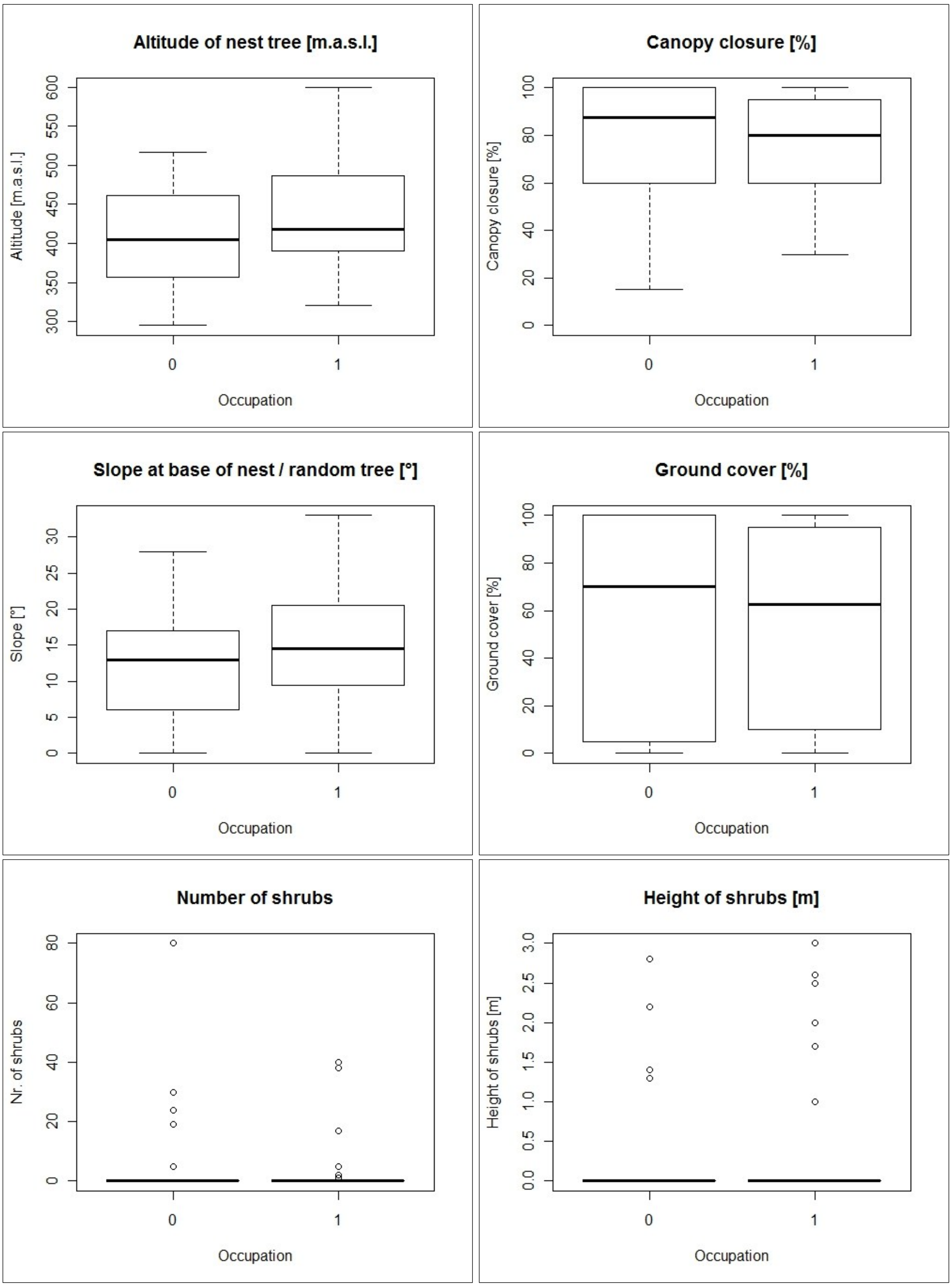


Appendix 6-6: Habitat variables not showing any significant differences between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = not occupied nest sites; 1 = occupied nest sites; [m] = metres; [g] = grams. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

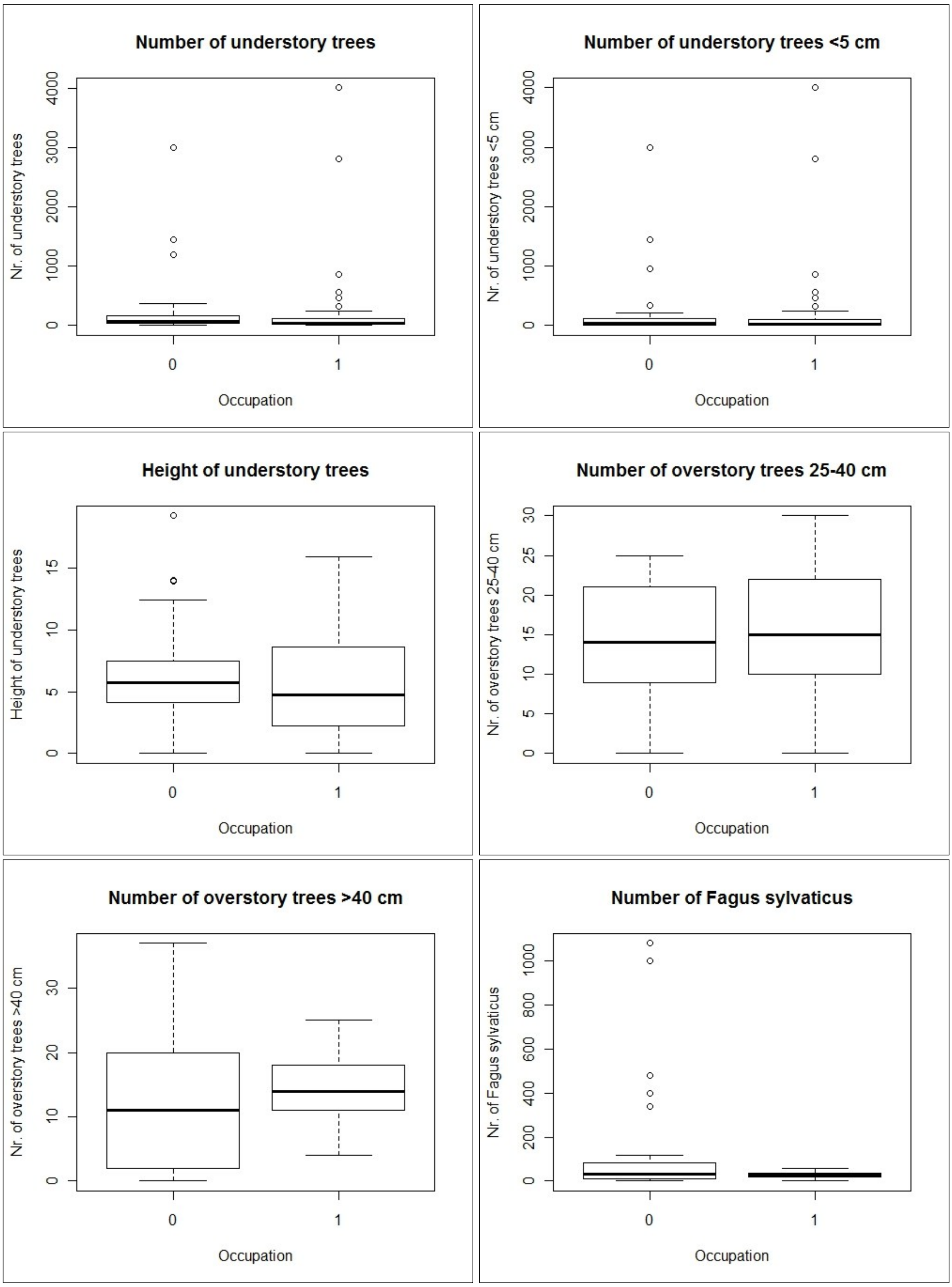


6.1.2 Comparisons between nest sites and random plots

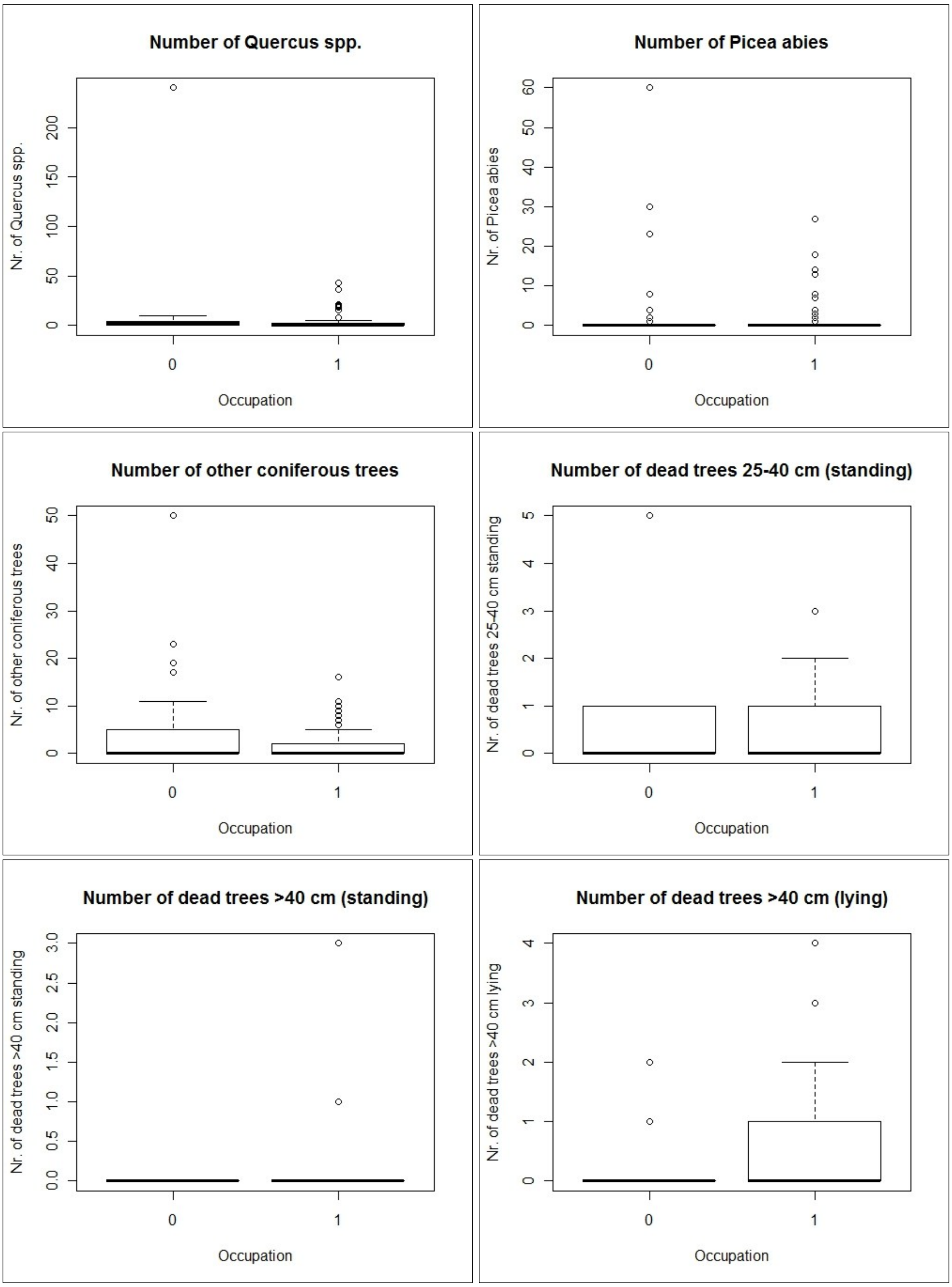
Appendix 6-7: Habitat variables not showing any significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = random plots; 1 = nest sites; [m. a. s. l.] = metres above sea level; [%] = per cent; [°] = degrees; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.



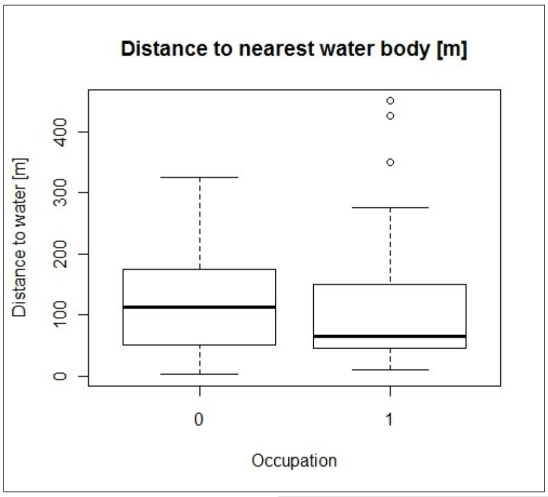
Appendix 6-8: Habitat variables not showing any significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = random plots; 1 = nest sites; cm = centimetres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

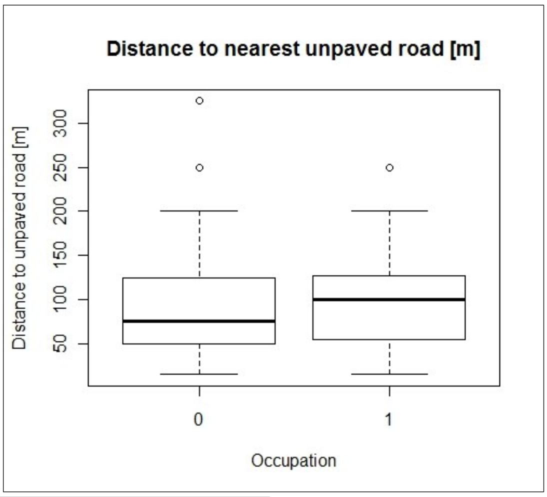


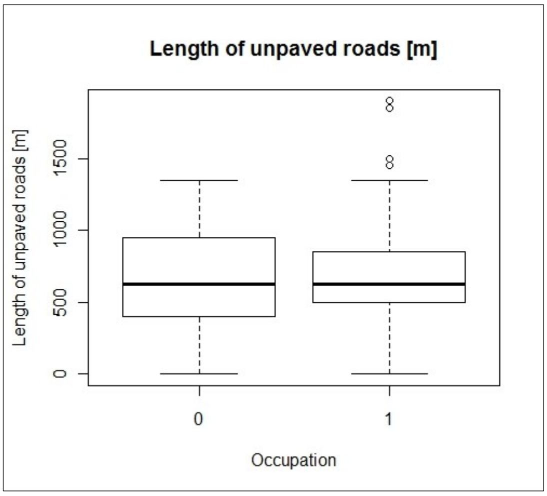
Appendix 6-9: Habitat variables not showing any significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = random plots; 1 = nest sites; cm = centimetres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.



Appendix 6-10: Habitat variables not showing any significant differences between potential nest sites of Tawny Owls (n = 60) and random plots (n = 30) in Student's t-tests and/or Mann-Whitney-Wilcoxon-tests and/or separate/ assembled logistic regressions. 0 = random plots; 1 = nest sites; [m] = metres. Bold line = median; lower/ upper whisker = minimum/ maximum, circles = outliers.

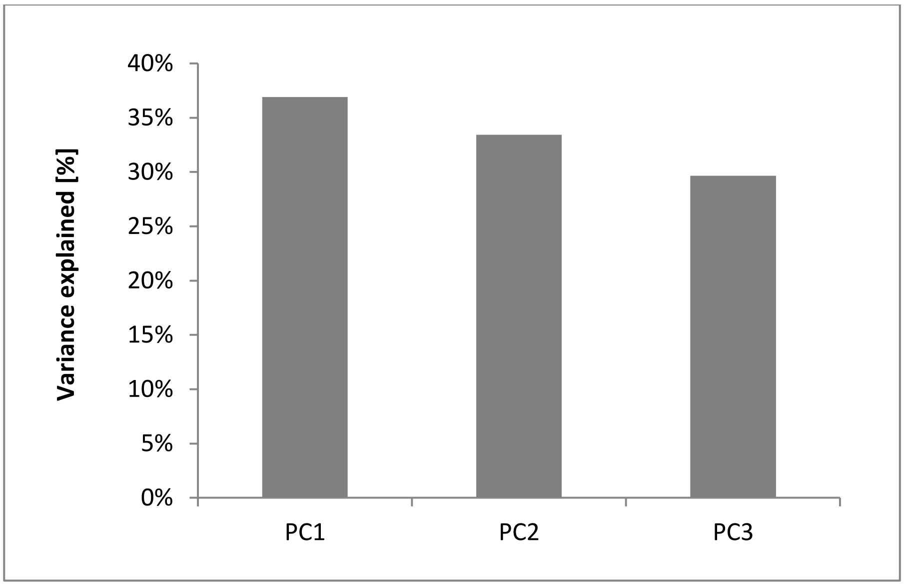




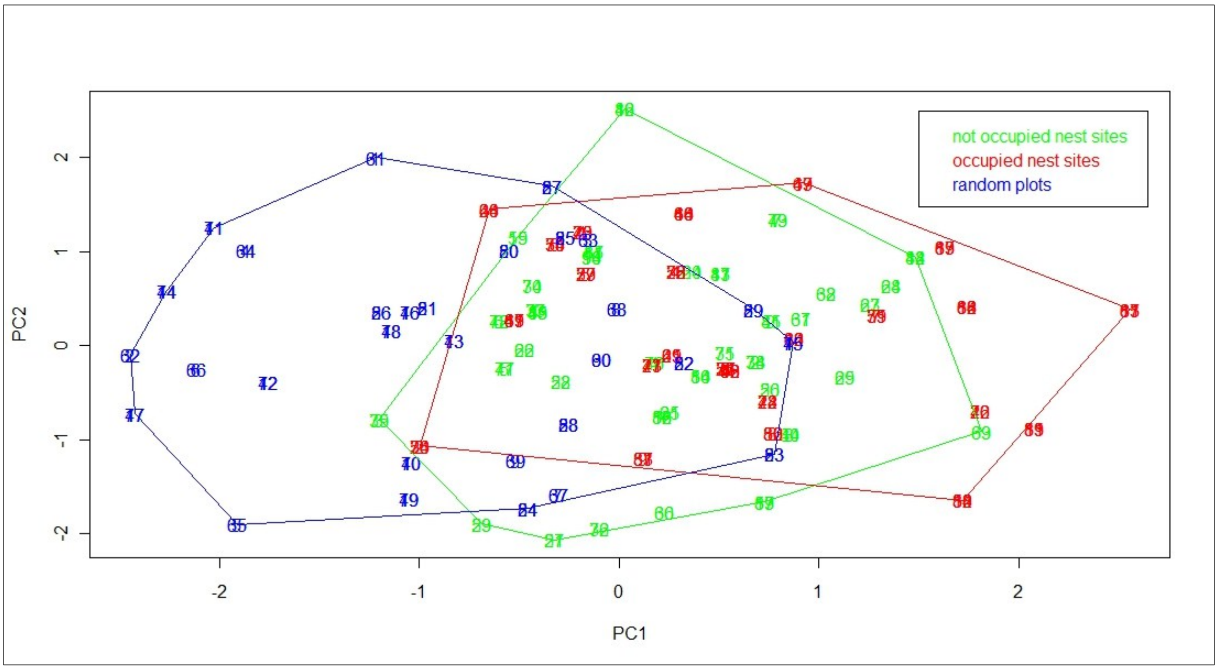


6.2 PCA of habitat variables of occupied and not occupied nest sites and random plots (not normally distributed variables excluded)

Appendix 6-11: Bar chart illustrating how much variance (in %) is explained by each PC (principal component) in the PCA (principal component analysis) comparing normally distributed habitat variables between nest sites occupied by Tawny Owls (n = 24), not occupied nest sites (n = 36) and random plots (n = 30).

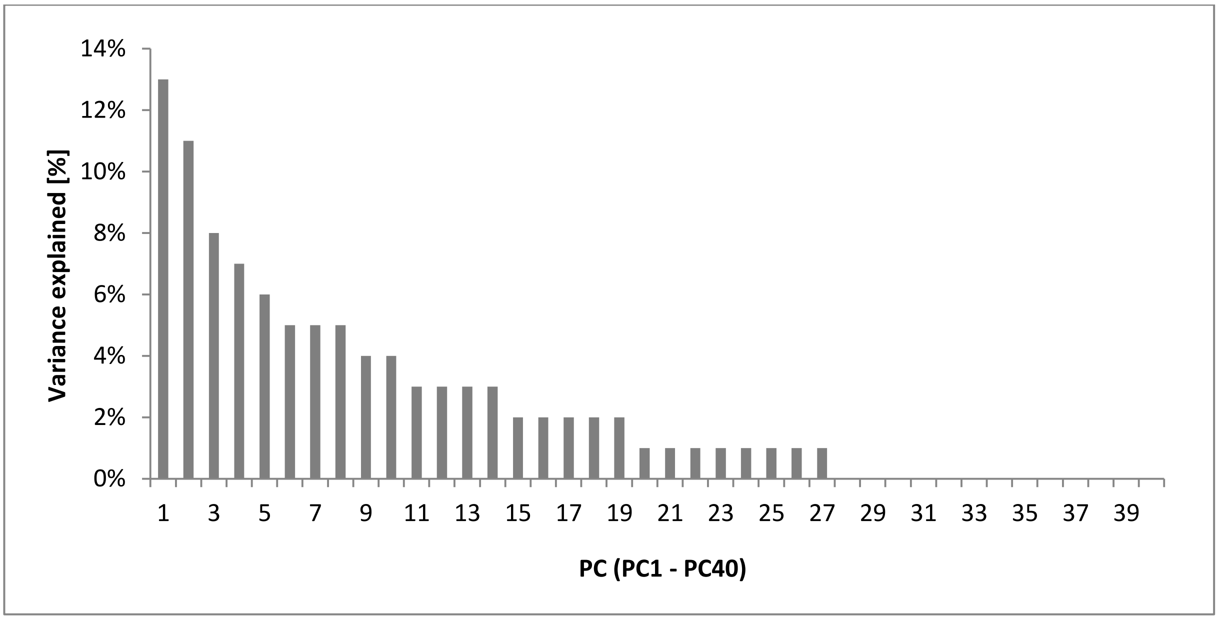


Appendix 6-12: Plot of PC1 (x-axis) against PC2 (y-axis) showing group separation of nest sites occupied by Tawny Owls (red; n = 24), not occupied nest sites (green; n = 36) and random plots (blue; n = 30).

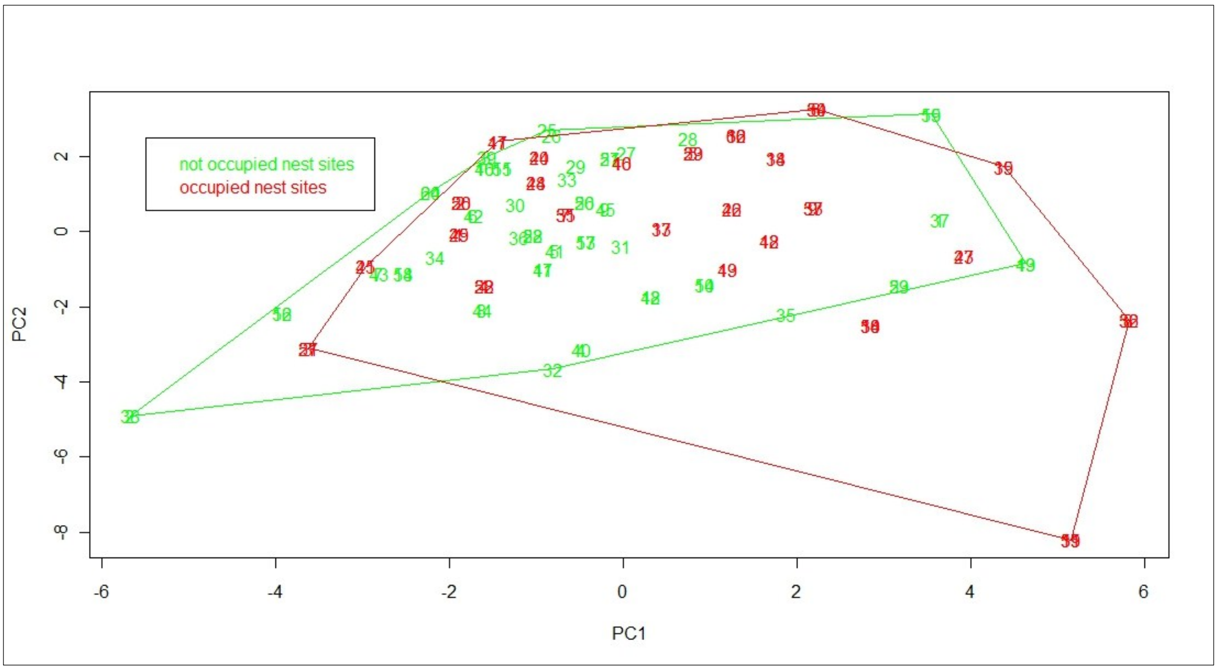


6.3 PCA of habitat variables of occupied and not occupied nest sites

Appendix 6-13: Bar chart illustrating how much variance (in %) is explained by each PC (principal component) in the PCA (principal component analysis) comparing habitat variables between nest sites occupied by Tawny Owls (n = 24) and not occupied nest sites (n = 36).



Appendix 6-14: Plot of PC1 (x-axis) against PC2 (y-axis) showing group separation of nest sites occupied by Tawny Owls (red; n = 24) and not occupied nest sites (green; n = 36).



6.4 Numbers and biomass of trapped rodents and mapped birds

6.4.1 Numbers and biomass of trapped rodents

Appendix 6-15: Numbers and biomass of the three different species of rodents (Bank Vole *Chletrionomys glareolus* [Schreber, 1780], Yellow-necked Mouse *Apodemus flavicollis* [Melchior, 1834], Wood Mouse *Apodemus sylvaticus* [Linnaeus, 1758]) trapped at the six trapping locations (M1-M6) in the study area. ∑ = total; [g] = grams.

Species	M1	M2	M3	M4	M5	M6	∑ number	∑ biomass [g]
MARCH								
Bank Vole	2	0	0	1	0	0	3	101,1
Yellow-necked Mouse	0	0	0	1	0	0	1	37,4
Wood Mouse	0	0	0	1	0	1	2	61,6
∑ March	**2**	**0**	**0**	**3**	**0**	**1**	**6**	**200,1**
APRIL								
Bank Vole	1	0	1	2	0	0	4	134,8
Yellow-necked Mouse	1	0	0	1	0	1	3	112,2
Wood Mouse	1	0	0	0	0	0	1	30,8
∑ April	**3**	**0**	**1**	**3**	**0**	**1**	**8**	**277,8**
MAY								
Bank Vole	0	0	1	4	0	0	5	168,5
Yellow-necked Mouse	0	0	0	1	0	2	3	112,2
Wood Mouse	2	0	0	1	0	0	3	92,4
∑ May	**2**	**0**	**1**	**6**	**0**	**2**	**11**	**373,1**
TOTAL	**7**	**0**	**2**	**12**	**0**	**4**	**25**	**851**

6.4.2 Numbers and biomass of mapped birds

Appendix 6-16: Total bird numbers and biomass of the bird species recorded at the six mapping locations (V1-V6) in March 2011. ∑ = total; [g] = grams.

MARCH	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**∑ number**	**∑ biomass [g]**
Black Woodpecker *Dryocopus martius* (Linnaeus, 1758)	1	1	0	0	0	0	2	600
European Goldfinch *Carduelis carduelis* (Linnaeus, 1758)	0	1	3	0	0	0	4	64
Treecreepers *Certhia* spp. (Linnaeus, 1758; Brehm, 1820)	0	1	0	0	0	0	1	9
Hawfinch *Coccothraustes coccothraustes* (Linnaeus, 1758)	0	0	0	0	0	10	10	550
Stock Dove *Columba oenas* (Linnaeus, 1758)	3	1	0	0	0	0	4	1100
Common Cuckoo *Cuculus canorus* (Linnaeus, 1758)	0	1	0	0	0	0	1	107
Great Spotted Woodpecker *Dendrocopos major* (Linnaeus, 1758)	8	6	6	0	1	1	22	1606
Middle Spotted Woodpecker *Dendrocopos medius* (Linnaeus, 1758)	1	1	0	0	0	0	2	118
Yellowhammer *Emberiza citrinella* (Linnaeus, 1758)	0	0	4	0	1	1	6	174
European Robin *Erithacus rubecula* (Linnaeus, 1758)	4	5	5	0	7	1	22	352
Collared Flycatcher *Ficedula albicollis* (Temminck, 1815)	0	0	0	0	0	0	0	0
European Pied Flycatcher *Ficedula hypoleuca* (Pallas, 1764)	0	0	0	0	0	0	0	0
Common Chaffinch *Fringilla coelebs* (Linnaeus, 1758)	13	11	5	14	10	17	70	1540
Eurasian Jay *Garrulus glandarius* (Linnaeus, 1758)	1	3	0	1	0	0	5	780
White Wagtail *Motacilla alba* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Grey Wagtail *Motacilla cinerea* (Tunstall, 1771)	0	0	0	0	1	0	1	17
Spotted Flycatcher *Muscicapa striata* (Pallas, 1764)	0	0	0	0	0	0	0	0
Eurasian Golden Oriole *Oriolus oriolus* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Coal Tit *Parus ater* (Linnaeus, 1758)	0	0	0	0	1	1	2	18
Blue Tit *Parus caeruleus* (Linnaeus, 1758)	12	9	9	8	4	2	44	484
Great Tit *Parus major* (Linnaeus, 1758)	8	17	16	10	14	8	73	1387
Willow Tit *Parus montanus* (Conrad von Baldenstein, 1827)	0	0	0	0	0	0	0	0
Marsh Tit *Parus palustris* (Linnaeus, 1758)	0	1	0	0	0	2	3	33
Black Redstart *Phoenicurus ochruros* (S.G. Gmelin, 1774)	0	0	0	2	0	0	2	34
Common Chiffchaff *Phylloscopus collybita* (Vieillot, 1817)	2	3	8	10	11	7	41	328
Wood Warbler *Phylloscopus sibilatrix* (Bechstein, 1793)	0	0	0	1	0	0	1	9
Woodpeckers *Picus* spp. (Linnaeus, 1758; Gmelin, 1788)	3	0	0	0	1	0	4	596
Dunnock *Prunella modularis* (Linnaeus, 1758)	0	0	0	0	1	0	1	18
Eurasian Bullfinch *Pyrrhula pyrrhula* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Common Firecrest *Regulus ignicapillus* (Temminck, 1820)	0	0	0	1	0	0	1	5
Goldcrest *Regulus regulus* (Linnaeus, 1758)	0	0	0	0	0	5	5	30
Eurasian Nuthatch *Sitta europaea* (Linnaeus, 1758)	11	11	9	6	6	4	47	940
Eurasian Collared Dove *Streptopelia decaocto* (Frivaldszky, 1838)	0	0	0	0	0	0	0	0
Common Starling *Sturnus vulgaris* (Linnaeus, 1758)	4	0	1	2	0	0	7	532
Eurasian Blackcap *Sylvia atricapilla* (Linnaeus, 1758)	3	4	5	2	2	3	19	342
Garden Warbler *Sylvia borin* (Boddaert, 1783)	0	0	0	0	1	0	1	19
Eurasian Wren *Troglodytes troglodytes* (Linnaeus, 1758)	1	2	3	1	1	1	9	81
Common Blackbird *Turdus merula* (Linnaeus, 1758)	5	7	11	5	5	1	34	2958
Song Thrush *Turdus philomelos* (Brehm, 1831)	0	6	1	4	5	2	18	1188
Unspecified	12	16	26	9	20	12	95	0
Σ	**92**	**107**	**112**	**76**	**92**	**78**	**557**	**16019**

Appendix 6-17: Total bird numbers and biomass of the bird species recorded at the six mapping locations (V1-V6) in April 2011. ∑ = total; [g] = grams.

APRIL	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**∑ number**	**∑ biomass [g]**
Black Woodpecker *Dryocopus martius* (Linnaeus, 1758)	3	2	0	0	0	0	5	1500
European Goldfinch *Carduelis carduelis* (Linnaeus, 1758)	0	1	1	1	0	0	3	48
Treecreepers *Certhia* spp. (Linnaeus, 1758; Brehm, 1820)	0	0	0	0	0	3	3	27
Hawfinch *Coccothraustes coccothraustes* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Stock Dove *Columba oenas* (Linnaeus, 1758)	5	2	0	3	1	0	11	3025
Common Cuckoo *Cuculus canorus* (Linnaeus, 1758)	0	2	0	0	0	1	3	321
Great Spotted Woodpecker *Dendrocopos major* (Linnaeus, 1758)	14	5	4	3	0	0	26	1898
Middle Spotted Woodpecker *Dendrocopos medius* (Linnaeus, 1758)	1	0	0	0	0	0	1	59
Yellowhammer *Emberiza citrinella* (Linnaeus, 1758)	0	0	4	0	1	1	6	174
European Robin *Erithacus rubecula* (Linnaeus, 1758)	4	0	2	0	4	2	12	192
Collared Flycatcher *Ficedula albicollis* (Temminck, 1815)	8	5	2	0	0	0	15	210
European Pied Flycatcher *Ficedula hypoleuca* (Pallas, 1764)	0	2	0	0	0	0	2	24
Common Chaffinch *Fringilla coelebs* (Linnaeus, 1758)	11	16	13	12	11	15	78	1716
Eurasian Jay *Garrulus glandarius* (Linnaeus, 1758)	0	0	1	0	0	0	1	156
White Wagtail *Motacilla alba* (Linnaeus, 1758)	0	0	0	0	0	1	1	21
Grey Wagtail *Motacilla cinerea* (Tunstall, 1771)	0	0	0	0	0	0	0	0
Spotted Flycatcher *Muscicapa striata* (Pallas, 1764)	1	0	0	0	0	0	1	15
Eurasian Golden Oriole *Oriolus oriolus* (Linnaeus, 1758)	0	0	3	0	0	0	3	210
Coal Tit *Parus ater* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Blue Tit *Parus caeruleus* (Linnaeus, 1758)	7	7	10	1	2	2	29	319
Great Tit *Parus major* (Linnaeus, 1758)	11	10	15	13	10	7	66	1254
Willow Tit *Parus montanus* (Conrad von Baldenstein, 1827)	0	0	0	0	0	1	1	11
Marsh Tit *Parus palustris* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Black Redstart *Phoenicurus ochruros* (S.G. Gmelin, 1774)	0	0	0	0	0	0	0	0
Common Chiffchaff *Phylloscopus collybita* (Vieillot, 1817)	0	4	8	7	5	4	28	224
Wood Warbler *Phylloscopus sibilatrix* (Bechstein, 1793)	0	0	0	4	0	0	4	36
Woodpeckers *Picus* spp. (Linnaeus, 1758; Gmelin, 1788)	0	0	0	0	0	0	0	0
Dunnock *Prunella modularis* (Linnaeus, 1758)	0	0	0	0	1	0	1	18
Eurasian Bullfinch *Pyrrhula pyrrhula* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Common Firecrest *Regulus ignicapillus* (Temminck, 1820)	0	0	0	1	0	0	1	5
Goldcrest *Regulus regulus* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Eurasian Nuthatch *Sitta europaea* (Linnaeus, 1758)	8	5	4	3	2	0	22	440
Eurasian Collared Dove *Streptopelia decaocto* (Frivaldszky, 1838)	0	0	0	0	0	0	0	0
Common Starling *Sturnus vulgaris* (Linnaeus, 1758)	8	0	2	2	0	0	12	912
Eurasian Blackcap *Sylvia atricapilla* (Linnaeus, 1758)	10	5	10	10	7	8	50	900
Garden Warbler *Sylvia borin* (Boddaert, 1783)	0	0	3	0	1	0	4	76
Eurasian Wren *Troglodytes troglodytes* (Linnaeus, 1758)	1	0	1	1	0	2	5	45
Common Blackbird *Turdus merula* (Linnaeus, 1758)	1	7	7	4	6	4	29	2523
Song Thrush *Turdus philomelos* (Brehm, 1831)	2	3	2	1	3	1	12	792
Unspecified	13	10	13	13	12	13	74	0
∑	**108**	**86**	**105**	**79**	**66**	**65**	**509**	**17151**

Appendix 6-18: Total bird numbers and biomass of the bird species recorded at the six mapping locations (V1-V6) in May 2011. ∑ = total; [g] = grams.

MAY	V1	V2	V3	V4	V5	V6	∑ number	∑ biomass [g]
Black Woodpecker *Dryocopus martius* (Linnaeus, 1758)	1	0	0	0	0	0	1	300
European Goldfinch *Carduelis carduelis* (Linnaeus, 1758)	0	0	0	1	0	0	1	16
Treecreepers *Certhia* spp. (Linnaeus, 1758; Brehm, 1820)	1	0	0	0	0	0	1	9
Hawfinch *Coccothraustes coccothraustes* (Linnaeus, 1758)	0	0	0	0	0	3	3	165
Stock Dove *Columba oenas* (Linnaeus, 1758)	0	1	0	3	1	0	5	1375
Common Cuckoo *Cuculus canorus* (Linnaeus, 1758)	1	1	0	0	0	3	5	535
Great Spotted Woodpecker *Dendrocopos major* (Linnaeus, 1758)	6	8	1	1	0	1	17	1241
Middle Spotted Woodpecker *Dendrocopos medius* (Linnaeus, 1758)	1	0	0	0	0	0	1	59
Yellowhammer *Emberiza citrinella* (Linnaeus, 1758)	0	0	4	2	1	1	8	232
European Robin *Erithacus rubecula* (Linnaeus, 1758)	6	7	4	5	4	6	32	512
Collared Flycatcher *Ficedula albicollis* (Temminck, 1815)	5	6	2	0	0	0	13	182
European Pied Flycatcher *Ficedula hypoleuca* (Pallas, 1764)	0	0	0	0	0	0	0	0
Common Chaffinch *Fringilla coelebs* (Linnaeus, 1758)	16	15	9	11	14	12	77	1694
Eurasian Jay *Garrulus glandarius* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
White Wagtail *Motacilla alba* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Grey Wagtail *Motacilla cinerea* (Tunstall, 1771)	0	0	0	0	0	0	0	0
Spotted Flycatcher *Muscicapa striata* (Pallas, 1764)	0	0	0	0	0	0	0	0
Eurasian Golden Oriole *Oriolus oriolus* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Coal Tit *Parus ater* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Blue Tit *Parus caeruleus* (Linnaeus, 1758)	6	2	3	3	2	3	19	209
Great Tit *Parus major* (Linnaeus, 1758)	14	16	13	15	10	5	73	1387
Willow Tit *Parus montanus* (Conrad von Baldenstein, 1827)	0	0	0	0	0	0	0	0
Marsh Tit *Parus palustris* (Linnaeus, 1758)	0	0	0	5	0	0	5	55
Black Redstart *Phoenicurus ochruros* (S.G. Gmelin, 1774)	0	0	0	1	0	0	1	17
Common Chiffchaff *Phylloscopus collybita* (Vieillot, 1817)	0	0	4	3	4	4	15	120
Wood Warbler *Phylloscopus sibilatrix* (Bechstein, 1793)	0	0	0	1	2	0	3	27
Woodpeckers *Picus* spp. (Linnaeus, 1758; Gmelin, 1788)	0	0	0	0	0	0	0	0
Dunnock *Prunella modularis* (Linnaeus, 1758)	0	0	0	0	0	0	0	0
Eurasian Bullfinch *Pyrrhula pyrrhula* (Linnaeus, 1758)	0	0	0	1	0	0	1	26
Common Firecrest *Regulus ignicapillus* (Temminck, 1820)	0	0	0	0	4	4	8	40
Goldcrest *Regulus regulus* (Linnaeus, 1758)	0	0	0	0	3	0	3	18
Eurasian Nuthatch *Sitta europaea* (Linnaeus, 1758)	9	9	4	0	0	1	23	460
Eurasian Collared Dove *Streptopelia decaocto* (Frivaldszky, 1838)	0	1	0	0	0	0	1	200
Common Starling *Sturnus vulgaris* (Linnaeus, 1758)	6	4	0	0	0	0	10	760
Eurasian Blackcap *Sylvia atricapilla* (Linnaeus, 1758)	5	8	5	12	11	11	52	936
Garden Warbler *Sylvia borin* (Boddaert, 1783)	0	0	2	0	2	0	4	76
Eurasian Wren *Troglodytes troglodytes* (Linnaeus, 1758)	1	4	2	0	3	3	13	117
Common Blackbird *Turdus merula* (Linnaeus, 1758)	3	6	7	8	4	2	30	2610
Song Thrush *Turdus philomelos* (Brehm, 1831)	3	5	3	3	1	1	16	1056
Unspecified	14	12	14	9	6	6	61	0
Σ	**98**	**105**	**77**	**84**	**72**	**66**	**502**	**14434**

7 Lebenslauf

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Ausbildung:

März 2011 – Feb. 2012	Masterarbeit „Nest Site Selection of Tawny Owls *Strix aluco* in Relation to Habitat Structure and Food Abundance in the Biosphere Reserve Wienerwald“
Sept. – Dez. 2010	Auslandssemester an der University of Ottawa in Kanada
2009 – 2012	Master-Studium der Zoologie an der Universität Wien
Juli – Aug. 2009	Bachelorarbeit „Vogelkartierung in den Zillertaler Alpen mithilfe der Punkt-Stopp-Methode“
2006 – 2009	Bachelor-Studium der Biologie an der Universität Wien
Juni 2006	Matura mit Auszeichnung bestanden
Oktober 2004	Schulreise nach Kanada
März 2001	Schulreise nach England
1998 – 2006	Besuch der Bilingualen Klasse (Deutsch – Englisch) am Akademischen Gymnasium Innsbruck

Praktika:

Juli 2010	Praktikum beim Habichtskauz-Wiederansiedlungsprojekt in Wien
August 2009	Praktikum beim Alpenzoo in Innsbruck
August 2008	Ehrenamtliches Praktikum bei der Vogelberingungsstation in Hohenau an der March
August 2007	Ehrenamtliches Berufspraktikum bei coopNatura in Innsbruck
August 2006	Freiwillige Helferin beim Tierheim Mentlberg in Innsbruck

Fremdsprachen:

Englisch	fließend (CAE 2005: Grade B, TOEFL 2010: Score 106)