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Forest Cover and Breeding Density of the Tawny Owl *Strix aluco* in Different Wood Types of Central Italy

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Zusammenfassung

Populationsgrößen von Waldbeutegreifern werden vom Anteil geeigneten übriggebliebenen Habitats bestimmt. Wir korrelieren den Anteil bewaldeter Flächen mit der Waldkauzdichte und pro Kauzterritorium mit 4 verschiedenen Laubwaldtypen entlang eines Höhengradienten in Zentralitalien. Altbestände von Küsten- und Eichenwald des Hügellandes beherbergen hohe Bestände dieser Eule, mit Abnahme in Stadt- und Bergbuchenwäldern. Dichteunterschiede ergeben sich bis auf einen Faktor 3 zwischen den unterschiedlichen Waldtypen und legen nahe, dass Waldtyp und -qualität einen direkten Einfluss auf die Brutdichte haben. Küsteneichenwälder liefern reichlich Nist- und Nahrungsmöglichkeiten wie auch mikroklimatisch günstige Bedingungen zur Jungenaufzucht und werden daher als optimal für den Waldkauz angesehen. Der Anteil Waldfläche pro Territorium ist etwa gleich in allen Waldtypen und legt nahe, dass die Minimum-Habitatansprüche des Waldkauzes vom Waldtyp abhängen. Unterschiedliche Managementstrategien zur Erhaltung hoher Populationen dieser Eule sollten daher unbedingt vom Waldtyp ausgehen.

Introduction

The area of suitable habitat may play a greater role than its spatial arrangements, and this is especially true for a landscape with a high proportion (i.e. more than 30 %) of suitable habitat left. A simple explanation for describing the effect of habitat fragmentation is that small habitat fragments are random samples from large ones. The random sample hypothesis suggests that the only consequence of habitat fragmentation is loss of habitat (e.g. ANDRÉN 1999). Forest cover may be correlated to species occurrence or population density to provide information on habitat suitability when different wood types are compared (e.g. ANDRÉN 1999, MONKKONEN & REUNANEN 1999).

The Tawny Owl *(Strix aluco)*, a territorial, rodent-eating raptor, is common in different forest types throughout Europe. Despite considerable interest in Tawny Owl ecology (e.g. SOUTHERN 1970, HIRONS 1985, PETTY 1989, GALEOTTI 1994, REDPATH 1995, RANAZZI et al. 2001), the relationship between population size and forest cover was not explored in a wide range of density and habitat proportion.

In this study we determined the dependence of breeding density and the amount of wooded areas *per Tawny Owl territory* on forest cover in four wood types of central Italy. Mediterranean forests along the elevation gradient represent an unique example of forested habitat containing an ample, plant and animal biological diversity, exemplified by the large number of tree species as compared to Nordic forests (SCARASCIA-MUGNOZZA et al. 2000). Despite

the explanatory limitations imposed by the descriptive nature of this study, our data may provide information useful for conservation and management planning.

Methods

This study was carried out from 1995 to 2000 in 42 selected woods with forest cover ranging between 6 % and 100 % of the whole census area along an elevation gradient (range: 10-1500 m) from coastal thermophilous oak woods to mountain beech woods in Latium and Abruzzo, central Italy (RANAZZI et al. 2001). The size of most forests was in the range 100-500 ha, with only a few > 2000 ha. All forests have been previously cut within the last 200 years. However, older forest patches with > 50 years of age are extremely common, and all forests are actually included in protected areas.

Occupied territories were censused by nocturnal playbacks of the male 'hoot' calls and by passive hearing for adults and young along transects of variable length depending on forest size from January to August of each year. The whole wooded surface was covered by transect routes. In homogenous forests > 500 ha only a part of the wooded area was censused, according to route facilities. Playback stations were located at 250 m distance (RANAZZI et al. 2001). To reduce disturbance by the acoustic stimulation to adults and owlets, we did not perform more than three visits during the same breeding season in the same area.

Individuals calling were located using 1:10 000 maps. In different visits, all neighbouring pairs or single males were stimulated when an unknown territory was located especially contacting males simultaneously calling along boundaries. Fledglings uttering the typical "ptziè" call helped us to locate the nesting area (RANAZZI et al. 2001). The centre of each territory was determined as the nesting area or the diurnal resting site (e.g. for single birds or for pairs that failed breeding) by searching for individuals resting on trees, as well as for feathers, droppings, and other traces, or by collecting pellets and prey remains. Census validation using individual recognition of hooting males by spectrogram analysis was described by RANAZZI et al. (2001).

We used the nearest-neighbour distance (n.n.d.) method (e.g. PENTERIANI & FAIVRE 1997) to estimate breeding density, which refers to the 1997 breeding season. Spacing was assessed using the centre of occupied territories. We chose this method to achieve comparable estimates of density and to correlate them to forest cover in all the census plots (PETTY 1989).

Forests were classified according to the dominant vegetation type (e.g. BLASI et al. 1999) as follows: (i) urban mixed woods, mainly composed of stands of *Platanus* sp., *Quercus ilex*, *Pinus pinea*, *Cupressus sempervirens*, and exotic vegetation; (ii) mountain beech woods, common up to 1000 m and represented by nearly pure stands of *Fagus sylvatica*; (iii) mesophilous oak woods, represented by mature stands of *Q. cerris*, *Q. frainetto*, *Q. robur*, and *F. sylvatica*, distributed between 200 m and 1000 m; and (iv) the termophilous oak woods, represented by mature stands of *Q. ilex* and *Q. suber*, common along the coastal belt and in neighbouring lowland zones.

The proportion of forested areas, used as descriptor of the amount of nesting habitat suitable for Tawny Owls, was measured in each census plot across the whole

'n.n.d. area' using aerial photographs, 1:10 000 maps, dot grids, and the VIDEOPLAN KONTRON PC package. The amount of wooded areas *per owl territory* was calculated by dividing the total surface of woods by the number of territories occupied across the whole 'n.n.d. area' (RANAZZI et al. 2001).

We assumed that the total number of individuals living in the original habitat has a one-to-one relationship to the proportion of the original habitat in the landscape. We tested this assumption by regressions between the log (population density) and the log (% original habitat in the landscape). The random sample hypothesis predicts a regression slope of 1 (e.g. ANDRÉN 1999). The dependence of breeding density and the amount of wooded areas *per owl territory* on forest cover was fitted by means of linear regression models. According to the random sample hypothesis applied to individual species, we assumed that the change in population size in relation to habitat fragmentation will be linearly related to the change in proportion of suitable habitat in the landscape. We compared the slopes of linear regressions between forest cover and breeding density testing the null hypothesis that slopes were identical among wood types (ZAR 1996). Minimum territory size was estimated in each wood type as 1/slope. Curve fits were obtained using PRISM 2.0 (GraphPad Software, 1995) PC package.

Results

A total of 561 territories was located in 42 census plots. The lowest densities (range: 0.8-5.2 territories km^{-2}) were recorded in mountain beech woods, the highest in thermophilous oak woods (2.0-14.3 territories km^{-2}). Regressions between the log (population density) and the log (% forested areas in the landscape) have a slope close to 1 in all the wood types (beech woods: $Y=1.19x-1.69$, $r^2=0.98$, $p<0.001$, $df=4$; urban mixed woods: $Y=0.98x-1.0$, $r^2=0.94$, $p<0.001$, $df=13$; mesophilous oak woods: $Y=1.20x-1.48$, $r^2=0.97$, $p<0.001$, $df=9$; thermophilous oak woods: $Y=1.0x-0.84$, $r^2=0.99$, $p<0.001$, $df=8$). The difference between slopes was not significant ($F_{3,37}=2.83$, $p=0.053$).

The correlation between population density and forest cover (Fig. 1) was significant in all habitats studied (beech woods: $Y=0.05x-0.57$, $r^2=0.94$, $p<0.001$, $df=4$; urban mixed woods: $Y=0.08x+0.33$, $r^2=0.95$, $p<0.001$, $df=13$; mesophilous oak woods: $Y=0.10x-1.22$, $r^2=0.91$, $p<0.001$, $df=9$; thermophilous oak woods: $Y=0.14x+0.07$, $r^2=0.99$, $p<0.001$, $df=8$). The difference between slopes was significant ($F_{3,37}=18.7$, $p<0.001$). Minimum territory size was 7.2 ha in thermophilous oak woods, 10.0 ha in mesophilous oak woods, 12.7 ha in urban mixed woods, and 18.1 ha in mountain beech woods. Conversely, forest cover did not affect the amount of wooded areas *per territory* except in mesophilous oak woods (beech woods: $Y=-0.09x+29.18$, $r^2=0.64$, $p=0.06$, $df=4$; urban mixed woods: $Y=0.02x+0.15$, $r^2=0.06$, $p=0.84$, $df=13$; mesophilous oak woods: $Y=-0.07x+18.32$, $r^2=0.71$, $p=0.001$, $df=9$; thermophilous oak woods: $Y=7.11$, $r^2=0.0$, $p=0.99$, $df=8$) (Fig. 2).

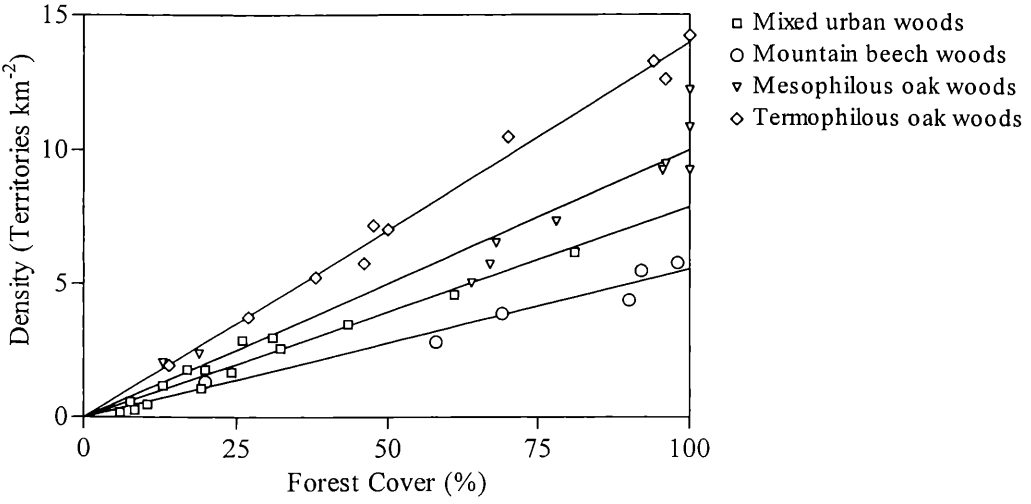

Fig. 1: Correlation between forest cover and breeding density of Tawny Owls in four wood types in central Italy. For graphical reasons, the Y-intercept value of each regression line was subtracted to density values in order to obtain regression lines with intercepts set to zero. – Abb. 1: Korrelation zwischen Waldbedeckung und Brutdichte des Waldkauzes in 4 verschiedenen Waldtypen Zentralitaliens. Aus graphischen Gründen wurde der Wert des Schnittpunktes jeder Regressionsgeraden mit der Y-Achse von den Dichtewerten subtrahiert, um alle Regressionsgeraden von Null ausgehen zu lassen.

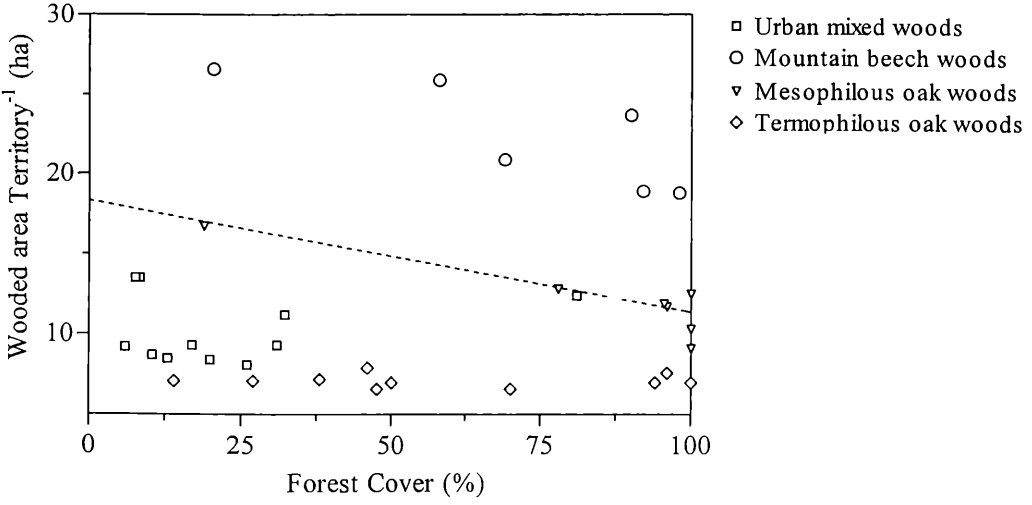

Fig. 2: Correlation between forest cover and wooded area per Tawny Owl territory in four wood types in central Italy. The dashed line indicates the regression line between wooded area per Tawny Owl territory and forest cover in mesophilous woods. – Abb. 2: Korrelation zwischen Waldbedeckung und Waldanteil pro Waldkauzterritorium in 4 Waldtypen Zentralitaliens. Gestrichelt: Regressionsgerade für mesophile Eichenwälder.

Discussion

The proportion of suitable habitat in the landscape is important in determining the spatial distribution of raptor territories (e.g. HIRONS 1985, REDPATH 1995, PENTERIANI & FAIVRE 1997). Notably, in a highly fragmented landscape in urban Rome, the proportion of wooded areas explained alone 80 % of the total variance in determining Tawny Owl density (RANAZZI et al. 2001). However, different landscape types may affect the colonisation probabilities of a habitat fragment (ANDRÉN 1999, MONKKONEN & REUNANEN 1999). Breeding density of Tawny Owls differed up to 3-fold between wood types, suggesting that forest quality influences density and regulates territorial defence (e.g. GALEOTTI 1994, REDPATH 1995).

Conversely, the amount of wooded areas *per territory* was unaffected by forest cover in all wood types but mesophilous oak woods. Moreover, the average requirement of wooded areas *per territory* was different among forest types, being high in beech forests with low prey abundance and reduced nest-site supply (e.g. PENTERIANI & FAIVRE 1997). The relationship between the amount of wooded areas *per territory* and forest cover in mesophilous oak woods may reflect different vegetation and climatic characteristics of the elevation range (200-1000 m) along which these woods are located.

ANDRÉN (1999) estimated critical threshold levels for many mammal and bird species to range between 10 % and 30 % of suitable habitats, but this result alone cannot be interpreted as a guide line in forest management for species with different habitat preferences and distributive patterns (MONKKONEN & REUNANEN 1999). Furthermore, a threshold in the proportion of suitable habitat in the landscape below which the species loss or decline in population size was greater than predicted from the random sample hypothesis is hardly detectable in species with a broad habitat distribution like the Tawny Owl (e.g. MONKKONEN & REUNANEN 1999). However, forest quality and the overall availability of forested areas could affect Tawny Owl density more than the fragmentation level (HIRONS 1985, PETTY 1989, RANAZZI et al. 2001).

Our data suggest that different management strategies in preserving local high densities of this owl should be undertaken strictly according to the forest type. Regulation of water captions from agricultural purposes and prevention of summer fires represent useful tools in the maintenance of good habitat quality of coastal forests, whereas nest-site supply should be increased by nest-boxes installation and by preserving isolated stands with old and dead trees in low-quality forests, like mountain beech woods.

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Summary

The proportion of suitable habitat left affects population features of woodland raptors. Here we correlated the proportion of forested areas with Tawny Owl *(Strix aluco)* density and the amount of wooded areas *per owl territory* recorded in four deciduous forest types along an elevation gradient in central Italy. Mature coastal and hilly oak forests supported high population levels of this owl which decreased in urban woods and in mountain beech woods. Density differed up to 3-fold among forest types, suggesting that forest type and quality has a direct effect in determining breeding density. Coastal oak forests provided abundant nest and food supply as well as microclimatic favourable conditions for chick rearing, and may be regarded as optimal for the Tawny Owl. The amount of wooded areas *per territory* is rather stable in all forest types, suggesting that the minimum habitat requirement of Tawny Owls depend on the forest type. Different management strategies in preserving local high-density populations of this owl should be undertaken strictly based on the forest type.

Key words: Tawny Owl, *Strix aluco*, population density, forest cover, wood type, central Italy.

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