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Bird species observed in a sample of eucalyptus from non-native species plantations: A case study (Mersin-Tarsus)

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Abstract: The possibility that new habitats resulting from silvicultural practices in Mediterranean coastal countries may have negative ecological impacts on existing biodiversity has often not been taken into account. For this reason, this study was carried out to determine the amount and diversity of bird species (breeding) in eucalyptus plantations. The study was carried out in eucalyptus plantations in a region located in Tarsus district of Mersin province in southern Turkey. Birds of three different age categories were observed at 22 points in the selected region. Vegetation parameters were measured by counting along transects 50 meters long and 10 meters wide in 4 main directions from the center of the points. As a result of this study, a total of 17 bird species were identified in these areas, and it was concluded that most of the bird species were underrepresented compared to the broadleaf forests. Eucalyptus plantations are far from being a supplementary forest habitat for bird species in the current region and provide an inadequate habitat. Birds that occupy these plantations are likely to benefit from an extended rotation time and retention of understory vegetation.

Keywords: Birds, Eucalyptus, plantations, biodiversity

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1. Introduction

Globally, there has been a strong interest of introducing non-native tree species in reforestation programs as a way of regaining important ecosystem services and provide biofuel and other wood products (Doughty, 2000; Dodet & Collet, 2012; Ennos et al., 2019). Parts of the Mediterranean basin has experienced extensive establishments of plantations using *Eucalyptus* spp., that is well-suited to the climatic conditions (Cerasoli et al., 2016). Establishing plantations of fast-growing *Eucalyptus* can be expected to affect biodiversity as a large tree habitat substitutes another type of habitat (often grass- or shrub-dominated). Furthermore, an *Eucalyptus* plantation may lack many features of native forests in the area that much of biodiversity is adapted to (Araujo, 1995; Badalamenti et al., 2018; Deus et al., 2018). For example, the fast growth and short rotation time of plantations create challenging aspects for native biodiversity. It is unclear to what extent the local native species can exploit the neo-habitat of *Eucalyptus* plantations. In this context, birds are often used as biological indicators to assess the potential of *Eucalyptus* plantations as surrogate habitats for native biodiversity. A number of studies conducted in the Western Mediterranean (e.g. Pina, 1989; Proença et al., 2010; Calviño-Cancela, 2013; Hanane et al., 2019; Goded et al., 2019 and Sertutxa et al., 2025) have pointed to a depauperate bird fauna in *Eucalyptus* plantations, lacking many species of specialists and harboring a lower number of generalists than native forests. Similar studies conducted in other parts of the Mediterranean, where environmental conditions and biodiversity may differ, are lacking. However, the need for comparative studies increases as *Eucalyptus* plantations are introduced to new regions at the expense of native habitats (Tomé et al., 2021; Zhang & Wang, 2021).

In this study, we set out to identify bird assemblages of plantations of non-native *Eucalyptus* in an area in southern Turkey where large stands have been gradually established during the last century. The approach was case-based, aiming at giving some preliminary insights to the richness and abundance of birds occupying these neo-habitats during breeding season. As the plantations are dynamic and vary in configuration depending on the time passed since last harvest, we also explored the associations between the bird community and vegetation structure of the plantations. Such results may be used as decision support to develop management that favor bird richness and diversity in plantations of non-native tree species.

2. Materıal And Method

2.1. Study area

The study was carried out in an area with *Eucalyptus* plantations located near the southern outskirts of the city of Tarsus in the Mediterranean part of southern Turkey (Figure 1).

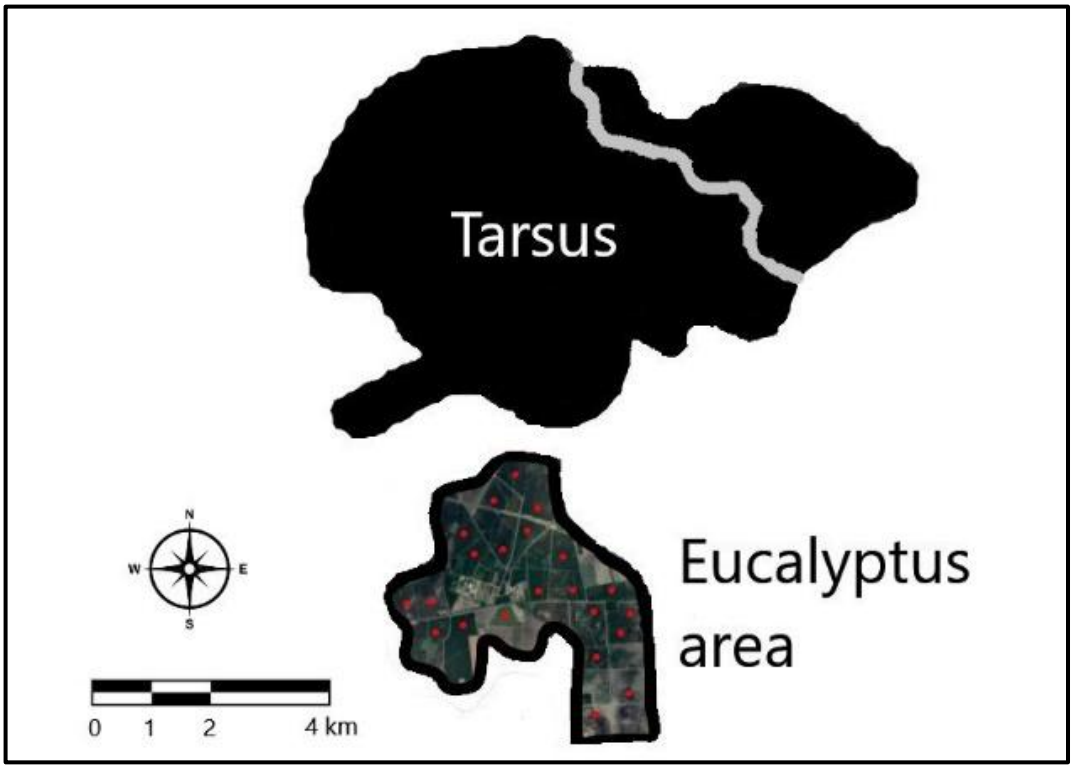

Figure 1. Study area just south of the city of Tarsus in the Mediterranean part of southern Turkey. The red dots represent the 22 surveying points.

The plantations consist of uniform stands of either *Eucalyptus camaldulensis* (90%) or *E. grandis* (10%). When established in 1939 the general objectives of the plantations were to facilitate marsh restoration (Yilmaz, 1998). They have eventually expanded to their present size of 885 ha. The plantations are currently managed for different research purposes run by the Eastern Mediterranean Forestry Research Institute in Tarsus. The harvested material is used mainly for industrial wood production but also medium-density fiberboard (mdf) and paper. The plantations are divided into well-defined stands belonging to different age categories ranging from stands that have been newly harvested to stands that are ready to be harvested. The general rotation time for most stands is limited to just ten years. A few stands have been subjected to extended rotation times to work as experimental control groups. Most plantations have a sparse structure of understory vegetation (mainly *Melissa* sp.) and are heavily grazed by domestic sheep belonging to nearby rural communities.

2.2. Bird inventories

During May and June 2019 (the main reason for the observations to be conducted in May and June only was because the primary aim of the study was to record the birds that utilize Eucalyptus plantations during the breeding season), breeding birds were surveyed in the central parts of 22 uniform Eucalyptus stands belonging to three distinct age-categories (see figures 2-4) using point counts with a defined radius of fifty meters, following Johnson (1995).

Figure 2. Photos showing the three age categories of *Eucalyptus*: young (above), medium (middle) and old (below).

Surveying was performed by one experienced observer during the first three hours after sunrise in order to cover the time of the highest avian activity. Birds were detected both visually using binoculars and by means of vocals in the often-dense vegetation. Most observations were of singing males. Birds that occasionally used the plantations as stop over during migration were disregarded from the study. For simplification we made the assumption that one territorial male was equal to one territory. The number of territories registered from each observation point was later recalculated as the number of territories per hectare.

2.3. Sampling of vegetation parameters

In the vicinity of each surveying point a number of vegetation parameters were sampled in order to characterize each stand. The density of tree trunks was calculated based on the number of trees counted along 50 meter long and 10 meter wide transects in the four major compass directions originating from the counting point. The diameter at breast height (dbh) of the very same trees were

measured to calculate the average basal area of tree trunks per hectare. The cover of shrubs and other understory vegetation was estimated in percentage using a method described by Göktepe et al., (2019).

2.4. Statistics

The data was analyzed mainly using linear regression to search for relationships between species diversity, territory density and vegetation parameters. The approach of this study was to explore and describe general trends, so there were no hypothesis s testing.

In order to explore the capacity of *Eucalyptus* plantations to harbor a certain bird assemblage there was a need to obtain data that can be translatable to resource availability. For this purpose, published information on body mass for the current bird species was extracted from Cramp (1985, 1988), Cramp and Brooks (1992), Cramp et al. (1993), Cramp and Perrins (1994a; 1994b), Cramp and Simmons (1980). For every species, the average weight of one male and one female was summarized and then multiplied by the number of territories found in each stand. The stand-wise sum of all species then represents the estimated bird biomass (denoted W). From these numbers the summarized metabolic weight (here denoted MW) was calculated for all species and stands according to Banavar et al., (2010) using the formula $MW = W^{(3/4)}$.

3. Results

3.1. Bird species richness and abundance

In general, there were low numbers of birds registered in most of the stands visited. One observation point did not yield any bird territories at all, and at most there were 17 territories registered from one observation point. In total 74 territories belonging to 17 species were recorded (Table 1).

Table 1. The 17 bird species registered in the *Eucalyptus* stands

English name	**Scientific name**	**English name**	**Scientific name**
Collared Dove	*Streptopelia decaocto*	Masked Shrike	*Lanius nubicus*
European Turtle Dove	*Streptopelia turtur*	White-spectacled Bulbul	*Pycnonotus xanthopygos*
White-breasted Kingfisher	*Halcyon smyrnensis*	Golden Oriole	*Oriolus oriolus*
Syrian Woodpecker	*Dendrocopus syriacus*	House Sparrow	*Passer domesticus*
Crested Lark	*Galerida cristata*	Spannish Sparrow	*Passer hispaniolensis*
Common Nightingale	*Luscinia megarhynchos*	Goldfinch	*Carduelis carduelis*
Blackbird	*Turdus merula*	Greenfinch	*Chloris chloris*
Eastern Olivaceous Warbler	*Iduna pallida*	Serin	*Serinus serinus*
Great Tit	*Parus major*		

Yielding an average bird density of just about 5.5 territories per hectare. If the over-aged *Eucalyptus* stands are disregarded, this number is lowered to just 4.6 territories per hectare. Across all stands, the three most abundant bird species were *Passer hispaniolensis*, *Lanius nubicus* and *Parus major*. Only minor differences in territory density were found between the low and medium age categories, whereas the few plantations of older control groups exhibited a higher territory density (Figure 5).

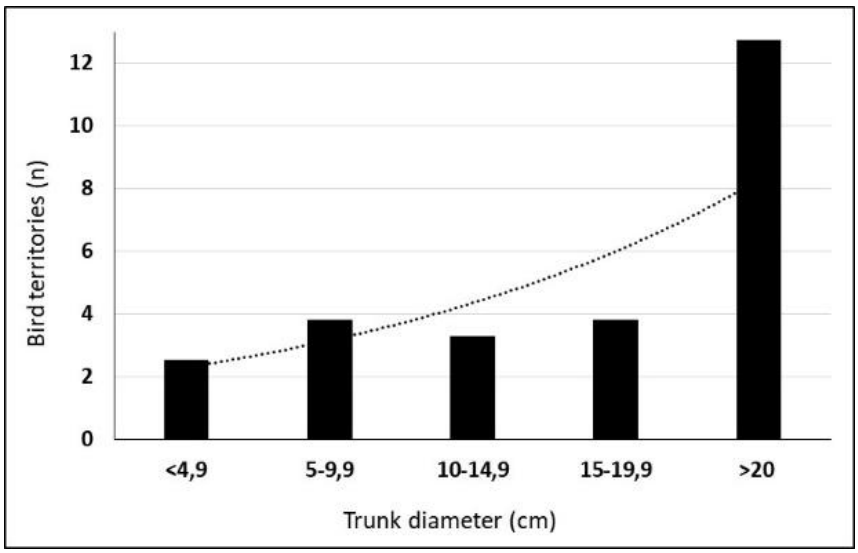

Figure 5. The average number of bird territories in *Eucalyptus* stands of different trunk diameters

Similarly, there was a tendency for a positive relationship between the territory density and the amount of vegetation in the plantation understory. Also, there was a tendency for an increase in the metabolic weight of the bird community with an increase in the basal area of tree trunks (Figure 6).

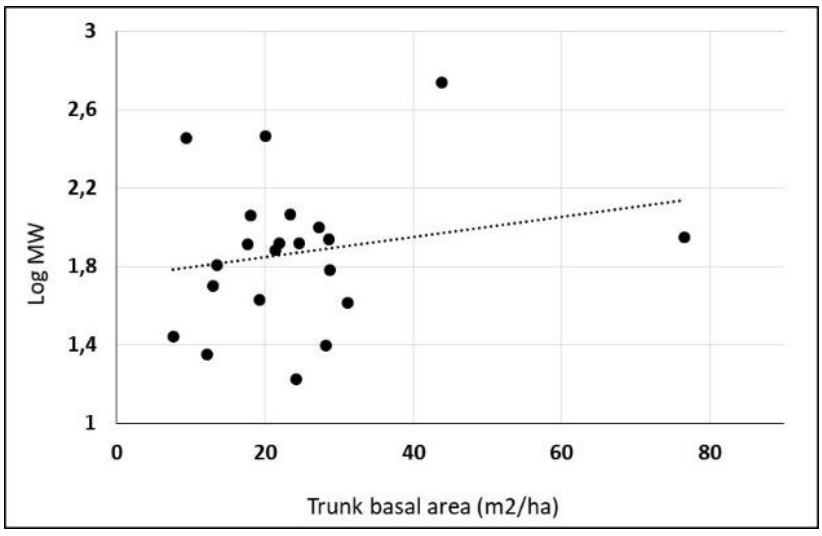

Figure 6. The function between the metabolic weight of the bird assemblages (transformed to logarithmic scale) and the basal area of tree trunks of *Eucalyptus* stands

For some of the species the relationships with *Eucalyptus* dbh and vegetation structure were more pronounced. For example, the ground dwelling *Galerida cristata* was typically seen only in

Eucalyptus stands recently harvested and not yet to develop a canopy, whereas the only territory of *Dendrocopus syriacus* was found in one of the older stands where a few trees contained cavities and dead wood presumably suitable for foraging. Even though the agricultural areas surrounding the *Eucalyptus* plantations contained irrigation canals, orchards and shrubby areas offering a relatively rich bird abundance, including *Prinia gracilis*, *Saxicola rubicola*, *Cettia cetti* and *Cisticola juncidis*, most *Eucalyptus* stands were species poor and harbored a different species composition.

3.2. Vegetation structure

Generally, there was a low inter-site variation in vegetation parameters among stands belonging to the same age category since the plantations are treated using the same rotation time and management (Table 2).

Table 2. Data on vegetation parameters measured in the *Eucalyptus* stands.

	Range	**Mean**	**S.D.**
Tree trunk density (n/ha)	110-215	158.4	25.6
Tree trunk diameter (cm)	4.8-43.8	14.7	8.1
Trunk basal area (m2/ha)	7.6-76.7	23.7	14.6
Shrub cover (%)	0-100	43	31.3

However, across stands there were larger differences as the structure of Eucalyptus stands are growing and developing after harvest. The variables with the most variation was the density of tree trunks per hectare as well as the amount of shrubs retained in the plantation understory.

4. Discussion And Conclusions

The current study represents one of the first in Turkey where the biodiversity of *Eucalyptus* plantations has been evaluated using birds as indicator organisms. The general findings are in line with those of previous studies conducted mainly in the Iberian Peninsula (e.g. Proença et al., 2010; Calviño-Cancela, 2013; Goded et al., 2019 and García-Fernández et al., 2025), suggesting that *Eucalyptus* plantations harbor a depauperate bird fauna including low numbers of both individuals and species. The low numbers can be exemplified using data on territory densities gathered in other forest habitats in Turkey. For example, compared to managed stands of oak (*Quercus* spp.) within the same part of Turkey (Bergner et al., 2015; Göktepe et al., 2019, Bergner et al., in prep.) the number of bird territories is on average 60 % lower in the *Eucalyptus* plantations evaluated here. A similar comparison from Galicia, Spain (López et al., 2018) found ever larger differences where the density of bird territories was as much as five times lower in Eucalyptus plantations (about 20 territories / 10 ha) compared to native oak forest (about 100 territories / 10 ha). Despite differences between different parts of the Mediterranean basin there are, without doubts, a substantial number of studies that have

concluded that *Eucalyptus* plantations is a poor supplementary forest habitat for birds. The reasons for this are thought to be a combination of the properties of the vegetation (e.g. fast growth) and the management applied to the plantations (e.g. early thinning and large-scale harvesting), and a non-native tree species that produce few insects (Wang et al., 2019). Firstly, due to the exceptionally fast growth of Eucalyptus trees the successional window offering optimal conditions for e.g. breeding is strictly limited for most species. This is particularly the case for forest specialists that depend upon complex vegetation structures and resources naturally developing over long time spans and at a reasonably slow pace. Such properties are virtually absent in plantations that are being managed for a simplified vertical structure (De la Hera et al., 2013). Secondly, previous studies have suggested that *Eucalyptus* plantations hold a lower diversity of both vascular plants and invertebrates (Zahn et al., 2009; Wang et al., 2011) which ultimately affects the niche width and resource availability for species of higher trophic levels, for example birds and small mammals (Calviño-Cancela et al., 2012; Carrilho et al., 2017). Due to limitations in resources, there is a considerable lack of functional diversity in managed *Eucalyptus* plantations (Jacoboski et al., 2016; Lemessa et al., 2022). Looking at the metabolic weight of the associated bird assemblages is an appropriate method of estimating the resource availability in a certain habitat. The data evaluated in this study indicate that the metabolic weight of birds increases with an increase in both *Eucalyptus* dbh and amount of understory vegetation, pointing to potential to take these parameters into consideration in forestry management to enhance resource availability. However, the number of experimental control groups of older *Eucalyptus* stands evaluated in this study is too low to give any conclusive results as to the strength and direction of these relationships. Further studies therefore are needed to elucidate this matter.

The *Eucalyptus* plantations evaluated in the current study have been continuously managed since the late 1930s, thus may be considered a well-established feature for the avifauna in this particular district. While the results yield an important description of the current situation, little or no clues are given to the ecological consequences of reforesting using *Eucalyptus* for the very first time. Reasonably, there are substantial differences in the initial responses of the avifauna to habitat transformation following establishment of *Eucalyptus* plantations depending on the characteristics and origin of the vegetation being transformed (Phifer et al., 2017). It is also likely that the responses differ depending on the spatial resolution, e.g. at a local scale or at the scale of larger landscapes and districts. However, since those aspects are little studied in the Mediterranean, knowledge from other parts of the world, including where *Eucalyptus* species are indigenous, might be useful.

The impacts on biodiversity are generally thought to be more severe for specialists, especially if *Eucalyptus* is introduced at the expense of native habitats. On the other hand, where *Eucalyptus* plantations replace degraded habitats that have lost vital ecological functions there is a possibility that

some species may instead find the new plantations as suitable supplementary habitats (Loyn et al., 2007). The spatial configuration and the traits of the habitats being transformed therefore are crucial aspects to consider in order to predict the impacts on their constituent species.

Where *Eucalyptus* plantations have been established there are measures that can be taken to improve the situation for the biodiversity living in or near the plantations. Apart from locating plantations to areas that are ecologically suitable, management methods can be adjusted to increase the variation within the plantations, for example retaining understory vegetation and native trees emerging and growing in the plantations (John & Kabigumila, 2011; Millan et al., 2015; Oxbrough et al., 2025). It can also be beneficial for biodiversity to extend the overall rotation time for entire stands, parts of stands or even individual trees within the stands as a way of increasing the overall niche width. The benefits gained by the adjusted management are expected to yield other values, for example improvements in ecosystem services which might increase the overall profit from plantation forestry (Brockerhoff et al., 2013).

As the use of *Eucalyptus* in the Mediterranean is expected to increase in the 21 Century, it is important to highlight the relationships with native habitats and biodiversity. So far, studies evaluating the ecological responses in certain groups of organisms are lacking. We call for additional studies using birds as biological indicators to describe and evaluate the species composition in differently vegetated habitats in the Mediterranean part of Turkey, from coastal grasslands to maquis shrublands and forest plantations comprising deciduous and coniferous trees as well as native and non-native ones. Such an approach can give important insights to the capacity of different habitats to harbor biodiversity under different types of management. Such studies can later be used to direct focus to less well-known groups of organisms and develop conservation priorities and habitat management that benefit a wider spectra of species.

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Conflict of Interest
The authors have no conflicts of interest to declare.

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