BREEDING BIOLOGY, POPULATION SIZE AND SPATIAL DISTRIBUTION OF A COMMON NIGHTINGALE (*Luscinia megarhynchos* Brehm, 1831) POPULATION AT YALINCAK (ANKARA)

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
BIOLOGY

DECEMBER 2005

Approval of the Graduate school of Natural and Applied Sciences

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ABSTRACT

BREEDING BIOLOGY, POPULATION SIZE AND SPATIAL DISTRIBUTION OF A COMMON NIGHTINGALE (*Luscinia megarhynchos* Brehm, 1831) POPULATION AT YALINCAK (ANKARA)

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December 2005, 68 pages

Many bird populations are known to show strong territoriality as well as high site fidelity during breeding. The Common Nightingale (*Luscinia megarhynchos*) is one of many such migratory species that annually occupies the same favourable habitat. Especially dominant males prefer to breed in the same area every year, and high fidelity probably assures high breeding success. This study aims to investigate breeding biology, population size and spatial distribution of nightingales at a small area in Yalıncak within the METU campus grounds (Ankara, Turkey).

From 2003 to 2005, birds were captured and marked with metal or colour rings or radio tags for monitoring. Analyses were carried out on 77 individuals, including ringing data from the previous two years.

Phenology of the study population was characterized by early arrival of males in late April, followed one week later by females. Nesting immediately followed and the first young fledged in early June. Second broods were also recorded. Most birds apparently left for the south within August.

The population in the 2.65 ha large area was estimated to be about 20-25 individuals. However, only 2-4 breeding territories were present and a large proportion of floaters existed. Territory sizes were smaller than reported elsewhere. Annual survival rate was 0.424 ± 0.121.

Contrary to previous knowledge, taxonomically the Yalıncak population belonged to subspecies *africana* although more westerly subspecies could be recorded during migration.

This study revealed the importance of small but productive biotopes as important breeding habitats for passerines. It also showed that a few highly successful individuals may contribute out of proportion to the next generation.

Keywords: Nightingale, breeding biology, site fidelity, territory, Ankara

ÖZ

YALINCAK'TA (ANKARA) BİR BÜLBÜL (*Luscinia megarhynchos* Brehm 1831) POPULASYONUNUN ÜREME BİYOLOJİSİ, POPULASYON BÜYÜKLÜĞÜ VE UZAMSAL DAĞILIMI

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Aralık 2005, 68 sayfa

Birçok kuş türünün üreme sırasında güçlü alan savunma davranışı ve alana yüksek bağlılık gösterdiği bilinmektedir. Bülbül (*Luscinia megarhynchos*) de her yıl aynı uygun yaşam alanını kullanan birçok göçmen türden biridir. Özellikle baskın bireyler her yıl aynı alanda üremeyi tercih etmektedir ve alana bağlılık büyük olasılıkla yüksek üreme başarısını sağlamaktadır. Bu çalışma ODTÜ (Ankara, Türkiye) yerleşkesi içinde bulunan Yalıncak'ın küçük bir bölgesindeki bülbül populasyonunun üreme biyolojisi, populasyon büyüklüğü ve uzamsal dağılımını araştırmayı amaçlamaktadır.

Kuşlar 2003-2005 yılları arasında yakalanmış, izlemek amacıyla metal halkalar, renkli halkalar ve radyo vericileri ile işaretlenmiştir. Analizler önceki iki yıla ait veriler de kullanılarak toplam 77 birey üzerinde gerçekleştirilmiştir.

Çalışılan populasyonun göç zamanlaması erkeklerin Nisan ayı sonunda erkenden alana ulaşması ve bir hafta sonra dişilerin gelişi olarak özetlenebilir. Dişilerin gelişinin hemen ardından yuva yapımı başlamış ve ilk yavrular Haziran başında yuvadan uçmuştur. Ayrıca bazı çiftlerde ikinci kuluçka da gözlenmiştir. Kuşların büyük çoğunluğu Ağustos ayında güneye göçmeye başlamıştır.

Toplam 2.65 hektar büyüklüğündeki alandaki populasyon büyüklüğü yaklaşık 20-25 birey arasında tahmin edilmiştir. Fakat alanda sadece 2-4 adet üreme bölgesi bulunmaktadır ve yüksek oranda üremeyen birey tespit edilmiştir. Üreme bölgesi büyüklükleri kaynaklardaki diğer alanlardan çok daha küçük olarak bulunmuştur. Yıllık hayatta kalma oranı ortalama olarak 0.424 ± 0.121'dir.

Daha önceki bilgilerin aksine, göç sırasında daha batıdaki populasyonlara ait bireyler yakalansa da, Yalıncak populasyonunun taksonomik olarak *africana* alttürüne ait olduğu bulunmuştur.

Bu çalışma küçük fakat verimli biyotopların ötücüler için önemli üreme alanı olarak önemini ortaya çıkarmıştır. Ayrıca üreme ve hayatta kalma başarısı yüksek olan bireylerin daha sonraki nesillere daha büyük oranda katkı yapabileceklerini göstermiştir.

Anahtar kelimeler: Bülbül, üreme biyolojisi, üreme alanına sadakat, alan savunma, Ankara

To my family

ACKNOWLEDGEMENTS

First of all, I must thank to my supervisor Can Bilgin for his invaluable support both in and out of the field. Without his guidance and patience, I would never be able to finish this study.

There are several people who have attended to my field studies, sacrificing their precious time for this study. Damla Beton, Elif Özcan, Özlem Öğün Çirli, Ayşe Turak, Gelincik Bilgin, Yasemin Bilgin, Cavit Bilen, Nermin Biltekin, Gencer Gencoğlu and Emre Öztürk have joined me several times and did not leave me alone in Yalıncak.

Özge Aydın and Gülden Atkın deserved special thanks for their efforts and support for my studies in their special project. I enjoyed every minute in Yalıncak with them.

Bird Research Society (Kuş Araştırmaları Derneği) has supported my study by providing necessary ringing and mist-netting equipments. And my colleagues, Okan Can and Bilge Bostan was always there to help me in troubled times. I thank you for making my life easier.

I have learned much from Özge Keşaplı Can, Özgür Keşaplı Didrickson and Jno Didrickson by helping them in other ringing stations. I have learned not only ringing, but also have shared their enthusiasm for this unexplored area of science in Turkey. And they all supported this station to be kept open for three years. It was a great pleasure to work with them; I hope we continue to work together for several years.

Dear Senem and Didem, I am proud of sharing my previous years with extraordinary people like you. We all share same dream of scientific success in Turkey, and I hope we will never give up. I look forward for our studies together in the future.

I would like to thank my family and all of my friends for their understanding and considerate behaviour in my stressful times. I found myself happy between them, even in times I was alone in the field.

Fidel must be remembered for his effort during these years, and making this thesis study more and more interesting.

Thanks for everybody for their support in my thesis and field studies.

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INTRODUCTION

1.1 Population dynamics in birds

Population dynamics, the study of fluctuations in numbers of natural populations of animals and plants, is of fundamental importance in ecology (Pielou, 1976). Changes in the number and composition of individuals in a population, and the factors that influence those changes reveal great importance in understanding the nature of these populations.

The size of a population can change with deaths, births, emigrations and immigrations. Immigration is the number or the rate of individuals that join to an open population from other populations in the environment. Emigration is, in contrast, the number or rate of individuals leaving the population in a unit time interval. Together with the rate of individuals born (birth rate) and dead (death rate) these are the four basic fundamental demographic parameters in any study of population dynamics (Begon and Mortimer, 1985). In the simplest form, the change in numbers of a population between two units in time can be formulated as:

$$N_{t+1}=N_t+B-D+I-E$$

Here, N_t is the number of individuals in the population at time t, N_{t+1} is the population size one unit time period after time t, whereas B is the number of individuals in this time interval, D is the number of individuals died between unit time t and t+1, I is the number of immigrants and E is the number of emigrants in the same time interval (Begon and Mortimer, 1985). The birth and death rates are generally incorporated in models as a function of N_t, a rate or a proportion of population size. The fecundity rate, N(*t*)*f*, is the average number individuals born per individuals alive at time t that survive to be counted at the next time step, t+1. The survival rate, N*(t)s*, is the proportion of individuals alive at time t that survive to the next time step (Akçakaya *et al*, 1999).

Generally, the immigration rate is not directly related with the population size. However emigration rate can also be written as a rate of N(t), based on assumption that where the number of population increases, number of emigrants also increase (Akçakaya *et al,* 1999). Thus formula, which is updated for a perennial species with open population, can be rewritten as:

$$N_{t+1}=N(t)s + N(t)f + N(t)e + I$$

In a more generalized form;

$$N(t+1)= N(t)\ (s+f+e) + I$$

The total of fecundity, survival and emigration rates gives a parameter called growth rate (R), which is described as the "finite rate of increase" in a population.

Survival, as described above, is the proportion of individuals in a population. In some cases mortality rates, complimentary to the survival rates, are used in calculations. Basically,

Mortality rate= 1 - Survival rate

There are several factors affecting the survival rate of individuals in the population. Resources (food, space, etc.), intraspecific and interspecific competition, density of predators, climatic conditions, parasites are among the environmental factors affecting survival rates. Also age and social position in territorial species can be counted as intrinsic factors affecting survival (Newton, 1998).

Fecundity is defined as the average number of offspring censused at a next time step.

$$F(t)=\frac{\text{offspring alive in } t+1}{\text{parents in } t}$$

Fecundity in birds has various components such as clutch size, number of broods, nest success, and juvenile and adult survival. Clutch size is the number of eggs laid in one brood. It can change from 12 eggs laid in 14 days in Blue Tit (*Parus caerulus),* to only one egg in 14 months by Wandering Albatross (*Diomedia exulans)*. Blue Tits, for example, can lay a second clutch of eggs in the same breeding season when their first brood is successfully fledged, thus they can increase their population up to 24-fold in one year (Newton, 1998). However, this high number of eggs and clutch size is an adaptation for low nest success and survival. Nest success is the number of eggs hatched from that nest in the breeding season. Juvenile survival is the survival rate of young to next year, which is in very low in many small birds. Thus, birds raising only one young per breeding season continue to feed and take care over the young even after it has fledged.

However, it is not always possible to define the dynamics of a population with these simple equations. As described above, each of these basic parameters are compounded from several other component processes (Begon & Mortimer, 1985). In some species, like annual plant populations, it is possible to assume that each individual is identical to each other in terms of survival and fecundity. But for many species, the age of an individual is one of its most important characteristics having strong effects on the individual's chances of survival and reproduction (Akçakaya *et al*., 1999). Thus, another model representing the differences of survival and reproduction between age classes should be applied; *age-structured model*. In age-structured model, survival and fecundity rates are determined for each age class.

In a simple model with 4 age classes, the diagrammatic life table and age-specific birth rates and survival rates will be like the following;

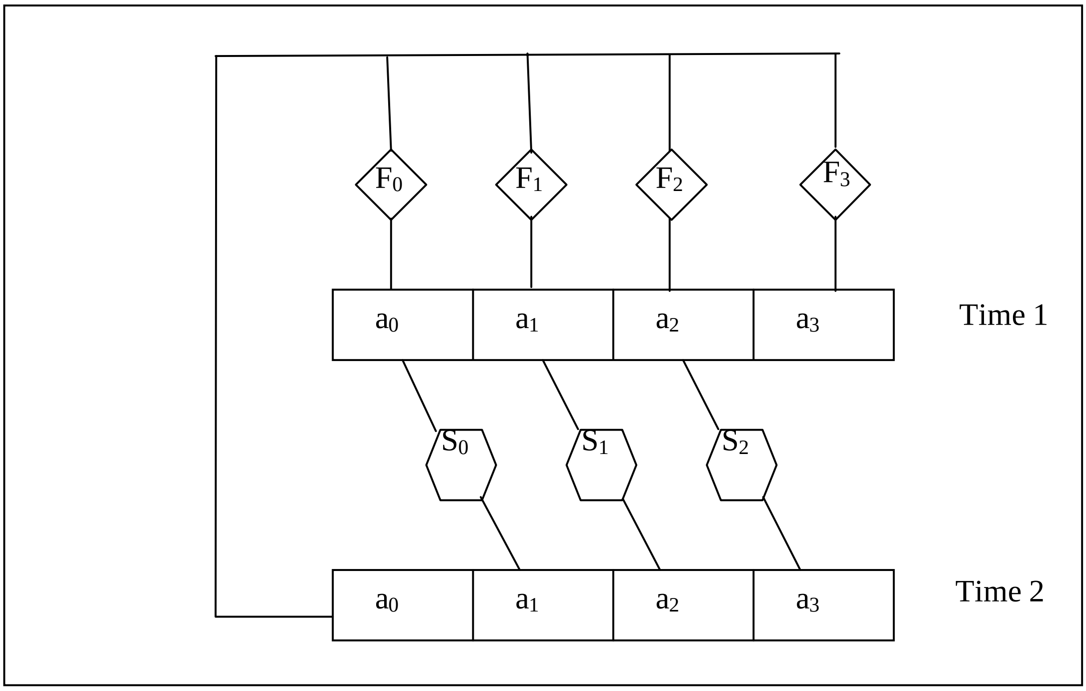

Figure 1 The diagrammatic life table for a population with overlapping generations, a's are age groups, F's age-specific fecundities and S's age-specific survivals (Begon & Mortimer, 1985).

Then, it is possible to calculate the size of age groups by the following equations (Begon & Mortimer, 1985);

$_{t2}a_0 = (_{t1}a_0 * F_0) + (_{t1}a_1 * F_1) + (_{t1}a_2 * F_2) + (_{t1}a_3 * F_3)$

$_{t2}a_1 = (_{t1}a_0 * S_0)$

$_{t2}a_2 = (_{t1}a_1 * S_1)$

$_{t2}a_3 = (_{t1}a_2 * S_2)$

Leslie (1945, cited in Begon & Mortimer, 1985) introduced matrices into population biology for easier expansion and expression of age structured models for higher age classes. The previous example could be derived as Leslie matrix;

$$\begin{bmatrix} \mathrm{t2a0} \\ t2a1 \\ t2a2 \\ t2a3 \end{bmatrix} = \begin{bmatrix} F0 & F1 & F2 & F3 \\ S0 & 0 & 0 & 0 \\ 0 & S1 & 0 & 0 \\ 0 & 0 & S2 & 0 \end{bmatrix} \times \begin{bmatrix} t1a0 \\ t1a1 \\ t1a2 \\ t1a3 \end{bmatrix}$$

After the matrix has been formed, the age specific survival and fecundity rates are put in table and calculated on the matrix. This representation can be used for calculation of age classed models for non-annual populations. It must be also taken into account when calculating fecundity rates; there are two types of census in population studies; pre-breeding census and post-breeding census. The census type is important in defining the maternity rate, and the survival of the 1st year individuals.

Several methods or equations can be developed in order to determine the dynamics of a population, but it is important to define the level of information needed. A model may be as simple as an equation with just one variable, or as complex as a computer algorithm with thousands of lines. One of the more difficult decisions in building models concerns the complexity of the model appropriate for a given situation, i.e., how much detail about the ecology of the species to add the model (Akçakaya *et al.*, 1999).

1.2 Use of mark-recapture for estimates of population size and survival

Mark-recapture technique is one of the methods to estimate the size of a population by capturing and marking the individuals and resampling them again to see what fraction of them carry marks (Krebs, 1999). Starting with C.G.J. Petersen in 1896, mark-recapture technique is now widely used for many purposes in biological sciences. It is a technique mostly used when data are required on highly mobile organisms or individuals. The strength of this technique is that it can provide data about birth, death and movement rates in addition to absolute abundance (Krebs, 1999).

Mark-recapture technique may be used on closed or open populations. When the size of a population is constant during the study, or in other terms the birth, death and migration in a population could be ignored, the population is called a closed population. Open populations, with a more acceptable assumption, are fluctuating in time in terms of population size (Krebs, 1999). The evaluation method of the results changes with the assumptions on the populations. Petersen method is used on closed populations and when there is single marking and single recapture effort. Schnabel method is for closed populations with multiple marking and recaptures. Jolly-Seber estimation method is used for open populations with multiple marking and recapture sessions (Krebs, 1999).

As the populations in natural environments are constantly changing in size as a result of births, deaths, immigration and emigrations, the Jolly-Seber method is used to estimate the open populations with a more realistic simulation. Jolly-Seber method has some assumptions;

- every individual has the same probability of being caught
- every individual has the same chance of survival between two time intervals
- individuals do not lose their marks, or marks are not overlooked at capture
- sampling time is negligible when compared to intervals between sampling

Based on these assumptions Jolly-Seber method estimates the total population number by the following formula;

$$Population\_size = \frac{size\_of\_marked\_population}{proportion\_of\_animals\_marked}$$

The proportion of marked animals to the total population can be estimated from the following formula (Seber, 1982, in Krebs, 1999);

$$\alpha = \frac{m+1}{n+1}$$

Where α is the proportion of the marked animals in the population, m is the number of marked individuals in the captured population in the specific time interval, n is the total number of captured animals. Seber (1982, in Krebs, 1999) showed that the size of the marked population could be estimated by;

$$M = \frac{(s+1)\times Z}{R+1} + m$$

M is the size of the marked population at time t, s is the number of individuals released after t, Z is the number of individuals marked before, not caught in t but caught in later sessions, R is the number of individuals released at time t and caught in later sessions, m is the number of marked animals caught in session t.

Thus, the size of population just before time t can be calculated as

$$N = \frac{\alpha}{M}$$

It is also possible to estimate of the loss and addition rate of the population from these estimates, but it is important to keep in mind that these estimates are interconnected and the fitness of one estimate affects all the estimates (Krebs, 1999).

1.3 Territoriality in birds

Territoriality is a result of contest competition among individuals. Territory can be defined as an area occupied less or more exclusively by an animal or group and defended by overt aggression and advertisement (Drickamer *et al.*, 1996). Newton (1998) defines the territorial behaviour as any form of spacing behaviour that involves site-specific dominance and that produces a dispersion pattern that, within the area occupied, is more regular than random.

Territoriality is a mechanism that regulates intraspecific competition. Pielou (1976) suggests that "competition takes place when the growth of a biological population, or any part of it, is slowed because at least one necessary factor is in short supply." From this definition we can conclude that existence of competition depends on the number of individuals in population. Thus, competition may be called a conditional density dependent factor, that is, conditional on the resource availability (Royama, 1992).

Territorial behaviour, or territoriality, can be seen as a result of competition, ending with dominance of a group or an individual over others. Several animals defend territories in different aggression levels. For example chipmunks defend their territories as a group, and several groups use same area, but the sleeping trees and core areas are defended strictly from other groups. Each group use the same area for feeding, but respects each other's core areas (Drickamer *et al.*, 1996). On the other hand, a wagtail can defend its territory by visiting the borders and resource-rich areas in appropriate intervals. No other individual, whether it's female or young, is allowed to enter the territory if resources are scarce (Davies & Houston, 1993 in Drickamer *et* *al.,* 1996). Conditions of territoriality depend upon its economic defendability, i.e. territories are defended only if the costs are outweighed by its benefits (Brown, 1969 in Drickamer *et al.,* 1996). Costs of foraging, advertisements and displays for defending the territory, threat of being injured in a territory fight or being detected by a predator while defending the territory are always taken into consideration while holding a territory (Thomas, 2000). Presence of dominant individuals around the territory as neighbours increase the chance of territory fights. The amount of resources available on the territory and chances of mating in territory determine the size of the territory. In such cases, birds tend to reduce the territory size to optimum extent, where the benefits of the territory is balanced by its costs (Norton *et al.*, 1982 in Drickamer *et al.,* 1996).

Depending on the conditions, birds may defend territories for whole year, or only in the breeding season. Migrating species can hold territories in both areas, also may defend temporary territories in the migration stop-over points. Some birds defend several kilometre-squares territories; others may tend to defend only the nest site.

To minimize the need for actual physical contact in order to defend territories, animals have evolved "keep-out" signals to warn away potential intruders. In birds, of course, the most prominent are the songs of males. Far from being beautiful bits of music intended to enliven the human environment (as was long assumed), bird songs are, in large part, announcements of ownership and threats of possible violent defence of a territory. If any intruder tends to ignore the audial warning, visual displays, chases and even fights will follow this intrusion.

1.4 Life history of the nightingale

The Nightingale (*Luscinia megarhynchos, C L Brehm, 1831*) is a small passerine that belongs to thrush family, *Turdidae*. It is a bird 16-16.5 cm in length, and has a wing span of 23-26 cm. Generally brown in colour; chest and belly is creamy white, turning to pale grey towards throat. Wings are paler than rump, but tail is reddish brown. It does not prefers to sing or feed in open places, generally seen at the last minute before flying into the middle of a bush, and thus tail colour is the most distinctive part generally observed. Sexes can not be identified in the field, but can be differentiated with the presence of “brood patch” in the hand. Young are spotted like other species in the thrush family.

Rather than its appearance, nightingale is mostly known for its famous song. Although it is singing during the day, nightingales are best known to be sing in night. This is why they are named after “night” in many languages. Nightingales sing during dawn and dusk. Songs reach its climax point approximately 1-2 hours before sunrise and birds continue singing all day.

Generally males are known to have a rich repertoire. Nightingales repertoire is estimated to be composed of 200 songs (Hultsch and Todt, 1982). Every individual learns to sing and develops his repertoire in his life-time. Nightingales are subjected to many tales, songs and poems in many cultures. They are said to be in love with the rose, in which it builds the nest. These animals are always in the attention of people with their continuous song in day and at night.

There are several theories on the reason of this diurnal singing in nightingales. The reason suggested is to attract the diurnally migrating females (Cramp, 1988; Glutz von Blotzheim, 1988). Although energetically costly, nocturnal singing can be accepted as honest signal on male quality (Catchpole & Slater, 1995 in Drickamer *et al.*, 1996). One of the recent studies on the singing frequency of nightingales suggests that nocturnal singing is directly related with the breeding status of the females. If males are unmated, they continue to sing until the end of breeding season. Mated males stop singing after mating, but start to sing when female is laying the eggs (Armhein *et al*, 2002).

The nightingale is distributed to Western and Central Europe, Balkans, Anatolia to steppes of Kazakhstan. On the northern parts of Europe, it is replaced by Thrush Nightingale (*Luscinia luscinia*). It prefers warmer and milder climates than Thrush Nightingale and can inhabit drier habitats. At the end of August, it migrates to Africa and winters between Sahara and rain forest from West Africa to Kenya (Cramp, 1988).

Eck (1975, in Cramp 1998) suggests there are 8 subspecies of nightingale in Europe. However, according to Cramp (1988), there are 3 subspecies of nightingales: Nominate *megarhynchos*, *africana*, and *hafizi*. Roselaar (1995) largely agrees on this division of subspecies, but adds the additional subspecies *baehrmanni*. Roselaar (1995) states that two subspecies of *L. megarhynchos* (*subsp. baehrmanni* and *subsp. africana)* exist in Turkey. There is an intermediate region where the subspecies could not be recognized, but a continuous cline in wing and tail lengths makes it difficult to identify subspecies boundaries.

1.5 Population parameters and territorial behaviour in nightingales

Nightingales are territorial birds. They hold territories both in breeding site and wintering site (Cramp, 1988). The famous song of the nightingale is a major warning to avoid unnecessary conflicts. Song amplitude is dependent on the noise in the background. Individuals do not maximize song amplitude normally, but may regulate vocal intensity depending on the level of masking noise (Brumm and Todt, 2001). If one individual enters the territory, full territorial song is given at the boundary. Also the bird accompanies threat bowing posture with alarm calls. Rivals approach each other singing and this duel may end with a chasing often followed with a bill fight (Cramp, 1988). Males defend territory in breeding range aggressively; in some cases birds from other species like Robin *Erithacus rubecula* and Redstart *Phoenicurus phoenicurus* are chased while trespassing the territory (Cramp, 1988). This aggression continues until the female lays the eggs. After the young are hatched and become independent moult starts and territories become loose. Several weeks later, the birds start to migrate.

It is also recorded that males continue to sing in migratory stop-over points. Nightingales also defend territories in winter ranges but the size of territories is small, and birds are less aggressive. Males do not sing at night in winter quarters, and diurnal songs are not so powerful and loud (Cramp, 1988).

Armhein *et al.* (2002) states that nocturnal songs of nightingales are more related with females' breeding cycle and males' mating status. Thus, diurnal song is related with territorial defence. This idea is supported by Cramp (1988) where the birds do not sing at night in winter quarters where they do not breed.

However, Naguib *et al.* (2001) suggests that birds defending a territory also use more space than its territory. Territories form 50% of used home-range and birds spend 10% of their time to forage and seek for mates in this outer territory. This outer territory is generally the territory of other individuals, so birds do not sing while they are out of their territory. This effort is made not only for finding more food, but also for making extra-pair copulations.

1.6 Objectives and scope

The aims of this study are:

- to determine the size of the population in Yalıncak
- to investigate the territorial behaviour of the individuals in the selected population
- to estimate the basic population parameters (like survival rate, fecundity, etc.) of the population
- to collect data on the phenology of the species.

CHAPTER 2

MATERIAL AND METHODS

2.1 Study area

The study was carried out in the METU campus area, Ankara (northwestern part of Central Anatolia). The study site is situated at 39º 52`05 N, 32º 47`22 E in south of the METU campus, near the ruins of the deserted Yalıncak village.

The study site which includes a small stream through the middle is vegetated by willow (*Salix spp.*) and poplar (*Populus spp.*) trees. Under these trees there is a dense cover of rosehip (*Rosa canina*) and other shrubs. Wild pear (*Pyrus eleagrifolia*), common hawthorn (*Crataegus monogyna*), and wild almond (*Prunus dulcis*) trees shorter than 6 m surround the study site. The studied area covers roughly 26500 square meters (2.65 hectares).

Figure 2 Aerial photo of the study site. The orange ellipse roughly denotes study boundaries. The short axis of the ellipse is about 100 meters.

The habitat has been shown to be a suitable stopover site for passerine migrants (Keşaplı Can, 2004; Keşaplı Can & Bilgin, 2006). It has been known to be inhabited by a small nightingale population for many years (C. Bilgin, unpubl. data). Rosehip shrubs are believed to be used for nesting, as they provide a relatively safe environment with many small thorns. Shrubs are spread along the stream and birds have been observed to feed on the insects on them.

2.2 Methods

The methodology was mainly based on the capture, ringing and recapture of individuals over three breeding seasons. Additionally site-referenced observations on transmitter-carrying, colour-ringed and singing individuals were used to determine territorial boundaries.

Figure 3 A view from the study site. Two net poles are visible as grey vertical lines.

2.2.1 Capture and metal ringing

Ringing (or banding) is a method to study different bird species; it is based on individual marking of birds. Animals are caught with different methods, and ringed by a trained ringer with a metal ring. Each ring has a unique number on it and also a standard address for recovery and retraps. Any record of a bird, either as a control at any other place or as dead, gives a lot of information about its life, particularly its movements, migratory routes, staging areas and also population parameters such as survival estimates and lifetime reproductive success (Wassenaar, 2003).

Figure 4 A ringed nightingale *(Luscinia megarhynchos)*

Starting in 2001, ringing in Turkey has accelerated in 2002 and 2003. The National Ringing Scheme, which was launched in 2002, is coordinated by Turkish Bird Research Society, and implemented in cooperation with the Ministry of Environment and Forestry, General Directorate of National Parks, and Middle East Technical University. As of the end of 2004, 90283 individual birds from 179 different species were ringed in 7 different stations in Turkey. (Keşaplı Can & Keşaplı Didrickson, 2005)

Ringing procedure includes capture of individuals, identification and ringing of species, and taking the necessary measurements. Birds are caught with mist nets, and ringed with steel rings 2.8 mm in diameter. First, the species is identified with help of identification books (Svensson, 1992). If possible, age and sex determination is made after the ring is fitted. Wing length, tail length, fat cover, and other variables are measured according to the procedure suggested in Busse (2000). After the measurements are completed, the individuals are weighed and then released.

Tail and wing measurements in the studied population, together with the data from Keşaplı Can (2004) were evaluated and investigated for subspecies determination. The most basic problem with the data is that it is not possible to differentiate the sexes, except at the height of the breeding season. The plumage is the same for both sexes in and out of the breeding season. Males can only be differentiated from the females by the size and shape of cloaca. The cloaca gets larger and longer than usual in males, especially in the breeding season (P. Busse, pers. comm.). Breeding females can be differentiated by the presence of a brood patch. Brood patch is an adaptation to incubate the eggs in the nest. The brooding parent sheds its belly feathers where they contact the eggs to pass its body heat better. In some species, both parents incubate the eggs, so both sexes may have brood patch. However, in nightingales males do not brood but feed the females in the incubation period (Hilprecht, 1954 in Cramp, 1988).

In this study, the birds were captured with mist-nets with a mesh size of 16 mm. The length of the net changed from 6-7 m. to 12 m. They were positioned to capture the highest number of nightingales.

Individuals were considered to be local birds unless they were captured only once or within less than two weeks' time during the migration period (April-May, August-September) and only non-juveniles were included in the the analysis.

Figure 5 The places of nets on the study site. Number of each net is given near the place. The blue ticks are points where the receiver is placed in tracking the radio transmitters

Total net length was 93 m in 2003, 89 m in 2004, and 100 m in 2005. A total of 51 days were spent in the field for capturing and ringing. Nets were opened half an hour after the sunrise and kept open until it gets completely dark in the dusk. Ringing was carried out for 15, 22 and 14 days for years 2003, 2004 and 2005, respectively.

Several days were also spent during tracking radio-tagged individuals and during searching for nests.

Table 1 Changes in the capture effort among years 2003-2005

Year	2003	2004	2005
Effort spent (day-meters)	1395	1958	1400
Days in the field	15	22	14

2.2.2 Colour ringing

In the first study year, birds were also ringed with plastic colour rings in order to enable the observer to identify them in the field remotely. Two rings were fitted just like metal rings but placed on the other leg with a different applicator and in different colour combinations. Previously recorded nightingale songs were also played in order to encourage the animals to show themselves.

2.2.3 Telemetry

Telemetry is a method where data is received from a distance. Radio telemetry applications on wildlife usually involve attaching to an individual animal a radio transmitter that transmits a unique electromagnetic signal. This signal is followed with a receiver and a directional antenna. Identification or determination of position is possible with use of standard techniques (Kenward, 1987).

Eight nightingales were studied with small radio tags in order to determine the home range and territories in the population. For this purpose, radio tags from Biotrack Ltd (Dorset, UK) with 0.5 g weight and range frequency of 150-151 Mhz were used. Also a telemetry receiver with antenna from AVM Instrument Co. Ltd. (California, USA) in this frequency range was used to follow the signals from different individuals. The radio tags were put on the birds by gluing on the back of the bird, or on top of the central tail feathers (Kenward, 1987).

In 2003 and 2004 radio tags were applied on individuals by harnesses made according to a procedure advised in Rappole & Tipton (1991), but the individuals quickly removed the harnesses. In latter trials, the birds removed the harnesses within 3 to 7 days. When the transmitter was glued on back of the bird, the birds removed the transmitter together with dorsal rump feathers in 2-3 days. Later, D. Mennill (pers. comm.) suggested a different kind of beading elastic cord which unfortunately could not be found in Turkey. V. Armhein (pers. comm.) suggested the loop harness method made from rubber cord with a total harness length of 47 mm. Alternatively, the method of gluing the transmitter on central tail feathers succeeded to keep the transmitter on the bird for a longer time. Thus, we preferred to continue using this method rather than insisting on the others.

After a transmitter was placed on the bird, each individual was tracked by a receiver from previously determined positions in thirty minutes intervals. With the help of a compass, the direction of the tracked bird to the reference point was determined for each transmitting bird. These were carried out for each individual active in the field and then the observer moved on to the next reference point. Each individual is tracked from each reference point every 30 minutes during tracking sessions.

2.2.4 Estimation of Parameters

The survival rate and approximation of total population in the area was done by program MARK (White & Burnham, 1999). MARK includes several models and to use on different populations.

Pollock (1982) proposed that far from Jolly-Seber method, the samples collected in longer time periods should have been evaluated as closed population models, and Jolly-Seber method should be used between periods. These suggestions helped much on reducing the bias from assumption of the same years' samples have the same parameter estimators. However taking samples in very short periods of time which can be assumed as closed populations; needs another set of methods for estimating abundance (Rexstad and Burnham, 1991).

By using Jolly-Seber estimators for survival rate and closed population estimators for abundance makes the overall analysis to be more robust to heterogeneity. There are no disadvantages of the method, whereas it has many advantages when compared to other two methods; a second source of information on detection probability, great heterogeneity in detection probability among species (Kendall, 2003).

CHAPTER 3

RESULTS & DISCUSSION

3.1 Capture statistics

A total of 56 different individuals have been captured 97 times between 29 April 2003 and 15 July 2005. Additional data belonging to 21 more individuals captured in 2001 and 2002 (Keşaplı Can, 2004) have also been incorporated in the analyses. These made the total data source based on 77 different individuals captured 156 times. Table 1 shows the number of individual birds ringed and recaptured between 2001 and 2005.

Table 2 Number of birds ringed and recaptured between 2001 and 2005

	2001	2002	2003	2004	2005
# of birds ringed	10	18	10	22	17
# of birds recaptured	0	4	6	4	2
Recapture rate (%)	-	22	60	18	12

As could be seen in Table 2, recapture rates have been fluctuating over the last three years; for example, in 2005, only 2 individuals from previous years were surviving (one of them is A0005, an extra-fit male).

Table 3 Distribution of ringed and recaptured birds among years

Ringing/recapture	2001	2002	2003	2004	2005
2001	10	4	3	2	1
2002		18	3	1	0
2003			10	1	0
2004				22	1
2005					17

There could be three different explanations for this decrease in recapture rate.

i) Individuals did not return from their migration: The birds may have not been able to survive during migration or in the wintering grounds.

ii) Individuals did not arrive at the study area: Site fidelity in birds is generally related to males' and females' breeding success in the previous year. Unsuccessful breeders of previous years may not return back to the area, but may disperse to the other habitats available in the vicinity (Switzer, 1997).

iii) Individuals have arrived to the study site but they were not caught by the nets: If there is a decrease in catching effort, either in time spent or in total net length, some marked individuals in the study site may not have been captured.

During the study (2003-2005) the effort spent for captures had changed slightly over the years. Therefore, the fluctuations may have been partly due to differential capture rates as well as possible high mortality during migration or in winter grounds.

Among the marked individuals there were 34 adults, 14 immatures and 17 juveniles. Due to the difficulty in sexing nightingales only 11 measurements in females and 12 measurements for males could be completed during the breeding seasons.

The basic measured variables differed significantly between females and males. Average values for each sex with probability levels are provided in Table 3.

Table 4 Weight, wing and tail length of non-juvenile females and males.

	Weight (g) *	Wing length (mm) ***	Tail length (mm) ***
Males (n=7)	22.19 ± 1.23	88.07 ± 1.68	75.50 ± 2.74
Females (n=10)	23.95 ± 3.19	83.78 ± 1.90	71.32 ± 2.05

** p<0.01, *** p<0.001

Males had distinctively longer wings and tails but females were heavier, at least during most of the breeding season.

3.2 Phenology

Timing is very important in terms of both survival and successful breeding in nightingales. As the nightingale is a migratory species, timing of migration is of adaptive significance. Nightingales hold territories in both wintering and breeding grounds, and the individuals reaching these grounds first keep better territories (generally the same each year) (Horskotte, 1969 in Cramp 1998). Thus, in the spring migration, older and fitter individuals, especially dominant males, start migration before females and less dominant males, arriving first to best habitat.

Earliest record for a nightingale in Yalıncak station is on 7th of April (in 2002). However, this individual does not seem to belong to the local population. The earliest arriving bird belonging to the Yalıncak population was A00005 (later named as Fidel, for its high fidelity to the site) which was captured earliest on 11th of April in 2002. In all years, this bird has been caught in the first days of field work. It can be concluded that A00005 is a dominant bird of the study site as suggested by Horskotte (1969 in Cramp, 1998).

A00005 was generally not observed at the site in the mid summer. Except for one record, all records were before the first half of June. Only in 2001, it was recorded on 9th of August. As Porter (1983, in Cramp, 1988) suggests that the peak in migration of nightingales is in late July or early August at Bosporus, the bird should leave its territory no later than the first week of August in order to arrive at winter grounds on time and hold a territory. However, some males have been observed even in September. Only two males, A00429 and A00311, were caught in Yalıncak in the second half of August. No other males, except for these two and A00005, have been observed or caught after June.

The latest record for a nightingale is on 13th of September (in 2002). Two nightingales, A00429 and JA11132, were recorded on this late date with a high rate of fat deposition. Their high scores of fat suggest that they have been preparing for this late move for a long time. A00429 was caught on 23rd of August in the previous encounter, had a fat rate of 4 and weighed 23.75 grams. After two weeks, he has loaded an extra 7.25 grams of fat to use in his exhausting journey to winter grounds. Surely, he could not hold a good territory after being so late, but if it started migration without preparation it could have died on the way to its winter quarters. Fat load is important because nightingales apparently cross large distances like Mediterranean

Sea and Sahara Desert in one continuous flight (Etchécopar and Hüe, 1967 in Cramp, 1988).

3.3 Territoriality

3.3.1 Identification efforts

Three different methods were used to identify individual birds. These are ringing (both metal and colour), continuous following of individuals that sing, and radio tagging.

Metal rings were durable and reliable for individual identification. No losses occurred and individuals ringed as early as 4 years ago were identified with the help of metal rings. However, this required the capture of the individual in the first place.

Colour rings potentially enabled the observer to identify birds through unique combination of colours. However, nightingales did not present themselves on open places like most other bird species, reducing chances of a definite identification. They preferred to stay in the centre of small shrubs while singing. Only one individual, apparently a dominant male, was observed with its coloured rings in singing activity.

None of the singing birds, except for one, responded to tape recording. The most dominant male showed itself on a high branch and started to sing while the tape was playing. Other birds could not respond or sing during tape playing.

Despite trial of several methods, the transmitters did not stay more than a few days on any bird. The birds removed the tag within usually a few hours. The only exception was the last trial when the transmitter stayed on the bird for up to two weeks, as it was attached to central tail feathers.

3.3.2 Territorial distribution

At the study site, two different types of territory have been observed, permanent territories and temporary territories. Permanent territories have been defended by more dominant males generally and continued to being defended till the end of the breeding season. Territory holders kept singing during day, and partly also at night, until the end of June. These territories seemed to be dissolved when the young have fledged and became independent.

Temporary territories were defended at the beginning of the breeding season but generally the territory holder stopped singing in the second half of May. It can be interpreted that these temporary territory holders could not succeed to attract a female in this time interval. Those territories were not defended in the second half of May or in June.

3.3.2.1 Territories in 2003

In 2003, two distinct territories were continuously defended by two dominant males. One of these permanent territories, hold by A00005, is the largest territory in the study area. Within this territory, A00005 was caught several times in the nets and was often observed (defined by its colour rings) singing from song posts.

Figure 6 The distribution of territories in 2003. Red: A00005, Yellow: A00311, Blue: A00429, Pink unknown male

Its territory includes the nets numbered 2, 6, 7, 8, and 11. The territorial behaviour was observed in the territory until the end of breeding season. In 2003, female with ring number B00093 was caught in the territory of A00005 in four different occasions. It had a brood patch in its belly, so it can be concluded that it was breeding that year. B00093 is concluded to be the mate of A00005 in 2003.

In 2003, the other permanent territory was thought to be held by A00429. Although direct identification by colour-rings was not possible, multiple recaptures within its presumed territory pointed to A00429 as the owner of that second territory. This territory has nearly 40% of its area within the study area. In 2003 it was not possible to determine the mate of this individual. Although we did not catch any females, the individual was concluded as a successful breeder, as it hold the territory till the end of the breeding season.

There were two other territories in 2003 within the study area. However these two territories were not strictly defended and the owners stopped singing in the middle of May. One of these territories was located in the middle of the study site, between the territories of A00005 and A00429. This territory includes the net numbered 3, and it probably belonged to A00311. A00311 was caught in net 3 and 6 in that year. Net 3 is in the middle of this territory and net 6 is located in the border with the territory of A00005.

The second temporary territory owner could not be identified because the territory was in the southeast corner of study site and included only Net 1. The territory owner did not defend this area too strongly and stopped singing in the second week of May. During this time we could not catch this individual and it is not possible to say anything about the owner of this territory. Overall, only 3 reproductively active males (defined by the size of the cloaca) were caught in 2003. This confirms the presence of only three territories within the study area.

3.3.2.2 Territories in 2004

In 2004, the positions of the nets were switched according to their frequency of catching nightingales and most potentially available net sites were used for a better resolution of territory boundaries.

Figure 7 The distribution of territories in 2004. Red: A00005, Blue: A00429, Yellow: Unknown male, Pink: unknown male

This year there were again two permanent territories and two temporary territories. The individuals A00005 and A00429 once more held the same territories. A00429 defended its northern territory with small changes on its boundaries. Again, no females were captured in A00429's territory, but he defended the territory until the end of the season. It can be predicted that that this pair built their nest in northern part of its territory, outside the study area. It was also noted that northern part of this territory hold more wild rose bushes, which the nightingales prefer to build their nests in their middle. In contrast, the southern part of this territory (covered by the study area) held more trees. Although A00429 extended its territory towards the southeast in 2004, it apparently did not have its nest on that part.

In 2004, A00005 did not change its territory's borders, and the size and shape were similar to the previous year. However, it is hard to determine the female of 2004 because 5 females were caught in this territory. All of them had brood patch, and nearly all of them were caught within the height of the breeding season. B00115 was the most frequently captured female in the area. She has been captured 6 times in 5 different nets in the territory. A radio transmitter was placed on her, and after two days it was found in the middle of A00005's territory. Therefore it can be concluded that B00115 paired with A00005 in 2004. A second female A00023 was caught twice in the territory in the middle of breeding season. It is possible that both A00023 and B00115 were mated to A00005. Although nightingales are generally monogamous, it is not uncommon that males sometimes breed with two different females (Davis, 1975; Clodius, 1894 in Cramp, 1988). As A00005 is a very dominant and successful male, and it is possible for him to pair with two different females. Other females captured are thought to have paired to different males in the area, as one of them was tracked with a transmitter. The shed transmitter was found in another territory outside of the study area, in north. The distance between the original capture site and the site transmitter had been found was roughly 250 m.

Temporary territories were again present in the area. The southern temporary territory was again inhabited by an unknown individual. Although one bird (B00113) was caught in the Net #1, which is within the territory, one cannot surely conclude it to be the territory holder. It was probably a male, since its wing length was 88. It was caught only once, in 23rd of April, and had a fat load of 4. This raises doubts about whether this bird belongs to the site or not. Whichever male was the territory owner; it defended until the middle of May and then stopped singing for the territory.

The second temporary territory was again in the middle of the study area, but in 2004 the borders had shifted a little bit. A00429 had moved its borders towards southeast into the study area, and in turn, this temporary territory shifted toward the southwest. This piece of habitat seemed to be more suitable for a territory, although the male defending this territory did not continue to hold it after the second week of June.

3.3.2.3 Territories in 2005

In 2005, A00005, or the male famously known as Fidel, was caught in the study site again. This individual has been captured for 5 years on row at the study site. Ö. Keşaplı Can (pers. comm.) stated that the individual was definitely an adult when it was captured in 2001. Although she did not take any data about the breeding status of the bird, it was obvious that the bird had been holding a territory. Because, the nets were placed in different positions in 2001 and 2002, they did not cover all of the study area at the time, being limited to the territory of A00005.

Figure 8 The distribution of territories in 2005. Red: A00005, Blue: B00141, Yellow: unknown male

A00005 was caught in spring 2001 when a pilot study for only one day was done on the field. Based on this information, A00005 must be in its second or third year when it was first ringed. In 2005, A00005 was in its 6^{th} or 7^{th} year. The longest record of a ringed nightingale is 7 years 11 months (Rydzewski, 1978 in Cramp, 1988). Even this makes A00005, namely Fidel, an especially important nightingale. Apart from its high survival rate, he has been a successful breeder for the last 5 years at the study site.

In 2005 only A00005 and B00128 were caught as controls (i.e. recaptures from previous years). Again A00005 held the same territory with same borders. It can be concluded that the territory size and productivity is optimum for this bird, which is dominant enough to enlarge its territory if needed. A00005, in its fifth year in the same territory, paired with B00128 in 2005. There was also another female caught in the same territory, which could again be a second mate in 2005. A third female was recorded in July, but this female, although it had a transmitter briefly, could not be followed or caught again.

A00429 was not caught in 2005. As a result of its absence, it can be concluded that it could not survive during migration or while in winter quarters. There was another male captured in that territory, B00141, which possibly replaced A00429. Again there were no records of a female for this territory.

There was another temporary territory, in the same place with previous years, but there is no strong evidence about the owner of this territory.

3.3.3 Extra-territorial forays

In this study, dominant males have been captured in nets outside their territory. A00005 was caught in net #5, which was in A00429's territory, on 10^{th} of June. A00429 was caught in net #6 on 4^{th} of May. There were other occasions where they have been captured in other nets, but recaptures in August or September are ignored as there is no territorial behaviour in these months.

Naguib *et al.* (2001) stated that male nightingales spend 10% of their time out of their territory without singing. This behaviour is thought to be made for extra resource evaluation and especially for extra pair copulations. Although paternity testing was not possible, and therefore biological parents of young are not known, such forays into neighbouring territories are thought to reflect similar motives.

3.3.4 Territory size

The mean territory size of nightingales has been reported to be 0.54 ha by Armhein *et al*. (2001), 0.67 ha by Grüll (1981), and 0.35 ha by Horskotte (1965). Grüll (1981) suggests that territory sizes are larger, 0.80 ha, in the beginning of breeding season and decreases to 0.55 ha after the neighbouring males are arrived. According to Rustamov (1982), territories are getting slightly larger after the breeding season has ended and the young have fledged (Cramp, 1988).

However, the data in Yalıncak does not correlate with these territory sizes. The total suitable habitat of study area covers only 0.90 ha in total, and there exists two to four territories within it. The approximate size of A00005's territory was estimated to be no more than 2500 square meters (i.e. 0.25 ha). Sizes of other territories were even smaller than this, making Yalıncak one of the most densely inhabited habitats reported for nightingales.

Stenger (1958) found a direct correlation between food supply and territory size; the more food available, the smaller the territory and the more there were. The size of the territory, then, is generally determined by population size and resource availability. The size of territories varies with the individual, the species, and the environmental conditions. Kendeigh (1941) also has shown that increased population size results in decreased territory size, up to a point. So there are maximum and minimum sizes of territories, the maximum size being controlled by defensibility and the minimum by density of resources.

Local distribution of nightingales seems to follow small streams as the riparian habitat is much more productive compared to drier uplands. Breeding territories are concentrated along these riparian corridors and may show some degree of compression due to high numbers of birds competing for space.

One explanation to this high density may be because of the lack of available habitats around Ankara. Yalıncak is stated as an important stopover site for migrants during migration season (Keşaplı Can, 2004). It is also important as being inside a natural area within Ankara not inhabited by humans. Like an island or oasis, surrounded with unsuitable habitats, it serves as an important resource for breeding and migratory populations. This importance is also proven by the high site-fidelity of the individuals in this population. Another evidence for this importance was proved by recapture of a Thrush Nightingale *(Luscinia luscinia)* in 2004 in the area, where it was originally ringed in 2002. After two years, this individual was caught in the same area, showing high site fidelity to its migratory stopover point.

3.3.5 Floaters

In several bird species non-territorial individuals are common. They are generally referred to as "floaters" and have been shown to visit breeding territories regularly (Smith, 1978, in Cramp, 1988; Zack & Stutchburry, 1992, in Armhein *et al.* 2004). In highly territorial species there are often many non-breeding males, which may defend a territory but after a certain time may desert it to settle somewhere else (Ligon, 1999 in Cramp 1998).

Annual number of floaters can be roughly estimated by counting the numbers of territorial individuals caught per year. There were three territorial males in the area in

2003; together with two females and fledged young of A00005, the total number of territorial individuals was 8. The remaining 8 of 16 individuals captured in 2003 were thought to be floaters (although a few of them may also be transient migrants).

In 2004, total number of captured territorial individuals were 12 consisting of 3 males, 2 females, and 7 young. Excluding territorial and migrating ones from the total number of individuals, the floater population could be estimated as 12.

Table 5 Number of males, females, young and suspected floaters per year. Individuals clearly on migration are excluded.

Year	Males	Females	Fledged young	Floaters	**Total**
2003	3	2	3	8	**16**
2004	3	2	7	12	**24**
2005	2	1	7	9	**19**

Similarly, the total number of floaters was 9 in 2005, whereas the number of territorial individuals was 10. Data from all three years indicate that at least half of the local nightingale population; or between up to 61 and 75 % of adults were floaters.

3.4 Population size and survival estimates

The population sizes were estimated for different years and are shown in Table 5. The study area seems to hold about 20-25 individuals on average. Population estimate for 2001 is higher than the others. However, for that first year variation is exceptionally high and therefore the estimate not very reliable. The higher estimate may also result from the high survival rate and high site fidelity of individuals that were captured that year.

Table 6 Estimated population size for different years.

	Estimates of Derived Parameters				
Population Estimates of {Huggins heterogeneity}					
				95% Confidence Interval	
Years	Session.	Estimated population size	Standard Error	Lower	Upper
2001	1	34.69	25.56	14.63	141.55
2002	2	26.34	2.84	23.35	35.99
2003	3	23.56	7.76	15.91	51.28
2004	4	28.80	5.84	22.33	47.85
2005	5	16.74	5.32	12.81	39.83

The annual survival rate was calculated as 0.424 ± 0.121 (95% CI being 0.218 - 0.659). This finding correlates well with that reported by Martin & Clobert (1996), who estimated a survival rate of 0.419 for European populations. In another study, Pons et al. (2003) found the annual survival as 0.464 ± 0.121 at a Mediterranean shrub site in southern France. The survival rate in Yalıncak nightingales seems to be comparable with those reported for other sites in Europe.

3.5 Breeding

Nightingales start to breed in their second calendar year; however, some exceptions of breeding at first year has also been noted (Grüll, 1981). Breeding starts with the arrival of females to the area. Males arrive at breeding grounds earlier and start to defend the territory by singing. Pair formation seems to occur within one week after arrival. After pair bonding has occurred, the female starts to build the nest (Horskotte, 1965; Stresseman, 1948 in Cramp, 1998). Breeding season is between the first week of May and second week of June. Each year females were first caught at beginning of May. There were no signs of brood patch during these encounters. When the females were caught a week later, the brood patch had already been formed. Thus, egg laying was predicted to be completed in the second week of May.

In 2003 and 2004, efforts for nest finding did not give any results, i.e. no nests could be found in the study area. In 2005, two nests were discovered. The nests were small and very well camouflaged in the middle of dense wild rose bushes; only after fitting an individual with a radio transmitter, they could be discovered.

Figure 9 The places of the discovered nests. Red line states the borders of A00005's territory.

The first nest was found on 14th of June in A00005's territory. With the help of the transmitter, the bird has been detected on the nest, incubating the eggs. The female flew away when approached to the nest. The nest was among the wild rose bushes, hard to detect, and roughly 20 cm from the ground as suggested by Cramp (1988). There were two eggs in the first week. In the second check, after 2 days, there were 4 eggs in the nest. However, on 20th of June, the nest was empty, probably destroyed by a predator. After the predation of the eggs in the first nest, the female laid a second clutch of eggs and started to incubate them.

Figure 10 The eggs in the nightingale nest

A second nest was found in 23rd of June. There were 5 eggs in the nest and it was built on a trunk of a tree approximately 2 meters high from the ground. Although this was an unexpected place for a nightingale nest, again it was very well camouflaged. After a week, in 1st of July the nest was deserted. This nest is thought to be deserted without any signs of outside disturbance. Probably the female stopped incubating as it was too late for raising young and at the same time preparing for migration.

This female, B00128, had a brood patch on 2nd of May in that same year, 2005, and two recently fledged young were caught within this territory in the beginning of June. This indicates that the nest found was the second clutch that B00128 was laying. After the second clutch was predated, the female probably continued to a third clutch, because in 2005 breeding started earlier than other years. However, migrants also need to moult their feathers for a successful migration, which needs extra energy. Therefore, the female probably deserted the nest without any outside negative influence.

Incubation lasts approximately 14 days after the eggs were laid (Cramp 1988). After the chicks hatch, they need an extra 11 days to fledge from the nest. So, when a newly fledged young was caught in the nest, the eggs could be assumed to be laid at least 25 days earlier. The young were caught on 3rd of June in 2005. To corroborate this finding, 31 days earlier on 2nd of May, B00128 was caught with a visible egg in belly.

Recently fledged young had a tail length around 40 mm when they were first caught. After two weeks, the tail length reached 70 mm. We can estimate approximate fledging time of each young from this information.

Table 7 Capture dates and estimated fledging dates of young

Ring number of individuals	Capture date	Estimated fledging date	Wing length (in mm)	Tail length (in mm)
B00103	July 11	July 5	74	56
B00104	July 11	July 5	75	52
B00105	July 11	Before June 30	84	71
B00123	June 19	June 19	71	39
B00124	June 26	Before June 10	87	74
B00125	June 26	June 18	84	60
B00126	June 26	June 18	83	62
B00127	July 2	Before June 18	83	73
B00130	July 2	Before June 18	86	75
B00133	July 8	Before June 25	85	75
B00148	June 3	June 1	68	44
B00151	June 3	June 1	70	42
B00152	June 4	June 1	73	45
B00153	June 22	Before June 10	82	71
B00155	June 22	Before June 10	84	71
B00156	June 23	Before June 10	82	70
B00159	July 15	July 5	82	69

The earliest fledgling dates were beginning of June in 2005, which was an exceptional year. In other years, first clutches seemed to fledge in the first half of June. Second clutches (including replacement clutches) fledged in late June to early July. At least for the territory of A00005, two broods per breeding season have been observed.

3.6 Taxonomic results

Three subspecies are generally accepted as races of this species: Nominate *megarhynchos* in Europe, *africana* in the Caucasus and the Middle East, and *hafizi* in Central Asia. Other forms suggested by Eck (1975), Parrot (1910), von Jordans (1924), Stresseman (1920), and Portenko (1950) are accepted as variations within the nominate subspecies. *L. m. hafizi* mainly differs from *megarhynchos* in plumage and wing size, but it is hard to determine for an untrained eye. Subspecies can be best determined with a bird in the hand. The distinct differences in plumage are greyer upperparts, sandy buff chest and virtually white underparts. The subspecies *africana* is intermediate between *hafizi* and *megarhynchos* (Cramp, 1988).

Cramp (1988) states that nominate subspecies *megarhynchos* is found in Europe, the Balkans and western Turkey. The subspecies *africana* is found in eastern Turkey, the Caucasus and Iran. The subspecies *hafizi* is distributed in the eastern parts of Aral Sea, from Eastern Iran to Mongolia.

However, Roselaar (1995) considers *baehrmanni* (as described from Macedonia by Eck, 1975) a valid subspecies. He claims that this taxon occurs east to at least a line from Zonguldak over Ankara to Çukurova delta.

Among the captured birds in this study, only 9 males and 14 females could be safely identified while measurements of 3 females could not be completed as the wing and tail feathers were much worn, which decreased the efficiency of measurements. Three additional males were measured only on the wing or the tail, as the rest was worn.

Table 8 Wing and tail measurements of males

Ring number	Wing length (mm)	Tail length (mm)	Wing/tail ratio
A00005	90,00	77,25	1,165
A00429	85,50	72,30	1,183
B00118	90,00	81,00	1,111
B00122	88,00	75,00	1,173
B00141	89,30	76,00	1,175
B00143	86,00	74,00	1,162
B00145	88,00	73,00	1,205

Table 9 Wing and tail measurements of females

Ring number	Wing length (mm)	Tail length (mm)	Wing/tail ratio
A00003	85,00	72,00	1,181
A00004	87,00	71,00	1,225
A00023	85,50	72,50	1,179
A00400	84,00	72,00	1,167
B00093	80,00	67,00	1,194
B00115	84,50	71,00	1,190
B00128	84,30	75,70	1,115
B00132	83,00	71,00	1,169
B00144	81,50	71,00	1,148
B00158	83,00	70,00	1,186

Cramp (1988), Stresseman (1920), and Loskot (1981) provide wing measurements of specimens belonging to subspecies *megarhynchos* as 83.9 (1.67 SD; n=28), 86.2 (1.75 SD; n=62) and 85.1 (2.65 SD; n=66), respectively. The published measurements for males and females of different subspecies are given in Table 10.

Table 10: **Wing-tail ratios in different subspecies. Taken from Cramp (1988)[1], Stresseman (1920)[2], Piechocki et al. (1982)[3], and Loskot, (1981)[4].**

Subspecies	Wing	Tail	Sex	Wing/tail ratio
megarhynchos [1]	83,9	64,5	♂	1,291
megarhynchos [1]	81,8	62,1	♀	1,319
megarhynchos [2]	86,2	--	♂	
megarhynchos [2]	82,8	--	♂	
hafizi [3]	94,7	--	♂	
megarhynchos [4]	85,1	68,9	♂	1,235
megarhynchos [4]	83,1	67,5	♀	1,231
africana [4]	86,2	74,1	♂	1,163
africana [4]	84,4	74,5	♀	1,133
hafizi [4]	91,2	81,2	♂	1,123
hafizi [4]	90,1	80,3	♀	1,122

When compared with data obtained during the study, it can easily be stated that these measurements corresponds to measurements of subspecies *africana*. Although there is some overlap with *megarhynchos* (or with *baehrmanni* if Roselaar (1995) is followed) in wing length, the tail is distinctively longer and thus associated with subspecies *africana*.

In subspecies determination, the wing-tail ratio of specimens is most useful. Even though sexes may have significantly differing wing and tail lengths, the ratio of wing to tail is typical for birds belonging to a particular geographical population regardless of sex (Roselaar, 1995).

Most local birds captured and measured were either intermediates between *baehrmanni* and *africana,* or typical *africana* with wings 80-91 mm, tails 67-81 mm and the wing/tail ratio 1.11-1.24. These values fall squarely within the ranges given for subsp. *africana* (wings 80-92, tails 67-85) while the diagnostic wing/tail ratio compares favourably with values (1.13-1.21) given in Cramp (1988) and Roselaar (1995). Only the measurements of two individuals fall into ranges for the nominate subspecies *megarhynchos* or subspecies *baehrmanni*, but these may be juveniles misidentified as adults or aberrant individuals (Figure 11). These results are contrary to what Roselaar (1995) claims, and moves the western range boundary of subspecies *africana* several hundred kilometres further west of Ankara.

Individuals that were assumed to be "non-locals" (n=14) had slightly shorter tails, and hence higher wing/tail ratios (Figure 11). The frequency distributions of wing/tail ratios for local versus non-local birds were found to be highly significantly different by a chi-square test (p=0.00045). This is not totally unexpected since birds breeding in eastern Europe (i.e. subsp. *baehrmanni* or the nominate subspecies) probably migrate over Turkey.

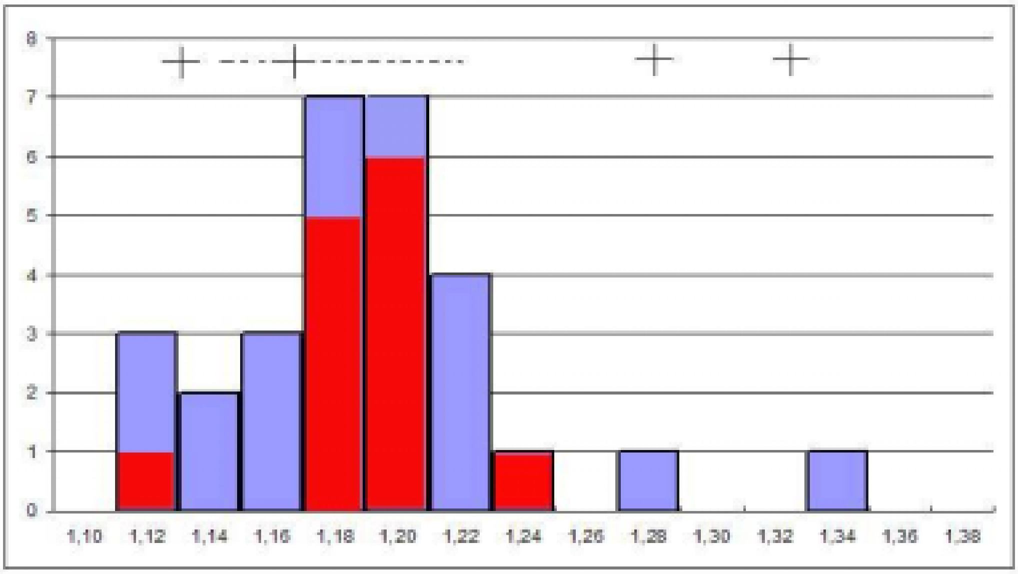

Figure 11: ***Wing/tail ratio for non-juvenile local individuals (n=29).*** **Blue squares represent non-breeding local individuals, red squares represent breeding individuals. Sexes are combined since the difference is not significant (p=0.165). Crosses represent average values for subsp. hafizi, africana, baehrmanni and megarhynchos, respectively. The dashed lines show range for subsp. africana (Roselaar, 1995)**

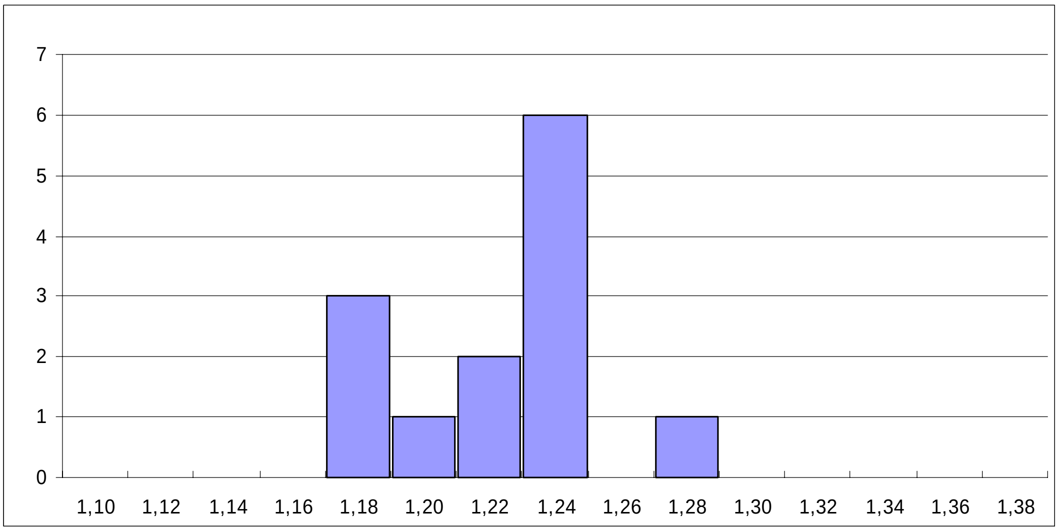

Figure 12 ***Wing/tail ratio for non-juvenile non-local individuals (n=13).***

The wing/tail ratios for subsp. *africana* and subsp. *hafizi* are rather more similar and the main difference is in the paler colors of the latter. The difference in plumages was hard to distinguish in this study as it was not possible to directly compare individuals with others. Nevertheless, the few individuals that had very long tails, and hence *hafizi*-like ratios did not show any paler colouration. Moreover, the range of *hafizi* is clearly to the east of the Caspian Sea in Turkistan and beyond.

Subspecies borders in *Luscinia megarhynchos* is not clearcut. Roselaar (1995) admits that *baehrmanni* probably grades into *africana*, and *africana* into *hafizi*. However, even if the species is made up of a series of overlapping populations that form a cline, birds from Yalıncak are closer in morphometry to birds described as subspecies *africana*.

CONCLUSION

Being the first study on nightingale in Turkey, this thesis presents a brief information on the phenology of the species. Although not evenly sampled, the arrival and departure dates of local migrants could be determined. As known from other studies, this migratory species prefers to breed in the same area every year. Some successful individuals succeeded to return back in its sixth year to the same territory in the breeding area. Dominant individuals protected their territories every year from the non-breeding floaters. The breeding males have been caught during their extra-territorial forays, which have been previously claimed to be existed.

Territory size is smaller than the records in literature, but this is concluded to be as a result of high productivity of the breeding ground. One dominant individual bred with two females in a year, or laid second clutch with same female. This confirms that the territory is highly productive.

High site fidelity and density shows the importance of the area, which is surrounded by unsuitable habitats for the species. The area is preferred by not only breeders but also passage migrant species. Conservation of such important habitats is very important in terms of survival of these populations

Subspecies determination from wing/tail ratio resulted in a different distribution of subspecies *africana* and *baehrmanni* from those suggested in literature. Most of the individuals belongs to subspecies *africana*.

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