Ela Foundation

ISSN 2319-4361
(Indexed in Google Scholar)

Volume 7 | Issue 3-4
July - December 2018

Ela Journal of Forestry and Wildlife

A quarterly scientific refereed e-Journal of Ela Foundation and Forest Department, Maharashtra for Nature Conservation through Education and Research

Barn Owl Special Issue

The Barn Owl *(Tyto alba)* in Turkey

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Citation: Göçer Elif and Johnson David H., (2018).
The Barn Owl *(Tyto alba)* in Turkey.
Ela Journal of Forestry and Wildlife
Vol. 7(3-4): 500-506

Date of Publication:
30 December 2018

ISSN 2319-4361

Photo by E. Göçer.

Figure 1. Male Barn Owl (*Tyto alba*) near Denizli, Turkey.

Abstract

We review the status, distribution, and ecology of the Barn Owl (*Tyto alba*) in Turkey. The owl is a regular breeding species and is generally distributed around the perimeter of the country. The taxonomy of the *T. alba* subspecies in Turkey remains unclear, with their being the potential for two or three subspecies present. Thus far, diet data on the species come from observational records and a number of pellet analysis papers. Overall, as there are few focused studies, the species is poorly known in Turkey. Since 1986, some new sources of Barn Owl data have been developed. We summarize these studies to highlight the status and informational needs for this species in Turkey. Detailed studies on the nesting, reproduction, genetics, and distributional surveys would yield important knowledge and management advances for the species in Turkey.

Introduction

The Barn Owl (*Tyto alba*) is one of the most well-studied owls in the world. However, due to its more limited numbers and distribution in Turkey, research and conservation work on it has proceeded slowly. Early work on the Barn Owl in Turkey comes from Erard & Etchécopar (1968), Kumerloeve (1975, 1986), Beaman (1986), and Kasparek (1992). A significant advance in our understanding of the Barn Owl came with the detailed work of Max Kasparek (1986), with his compilation of observations, distribution map, and insights into the taxonomy of the owl in Turkey. In the subsequent 30 years, some 22 sources of material relevant to the Barn Owl have come about (20 publications and reports, one land use law, and the eBird data system). Our objective is to summarize these latter materials, and update the understanding of the owl in Turkey.

Legal Status

The main legal protection offered to wildlife in Turkey is under the Land Hunting Law, No. 4195, accepted 7

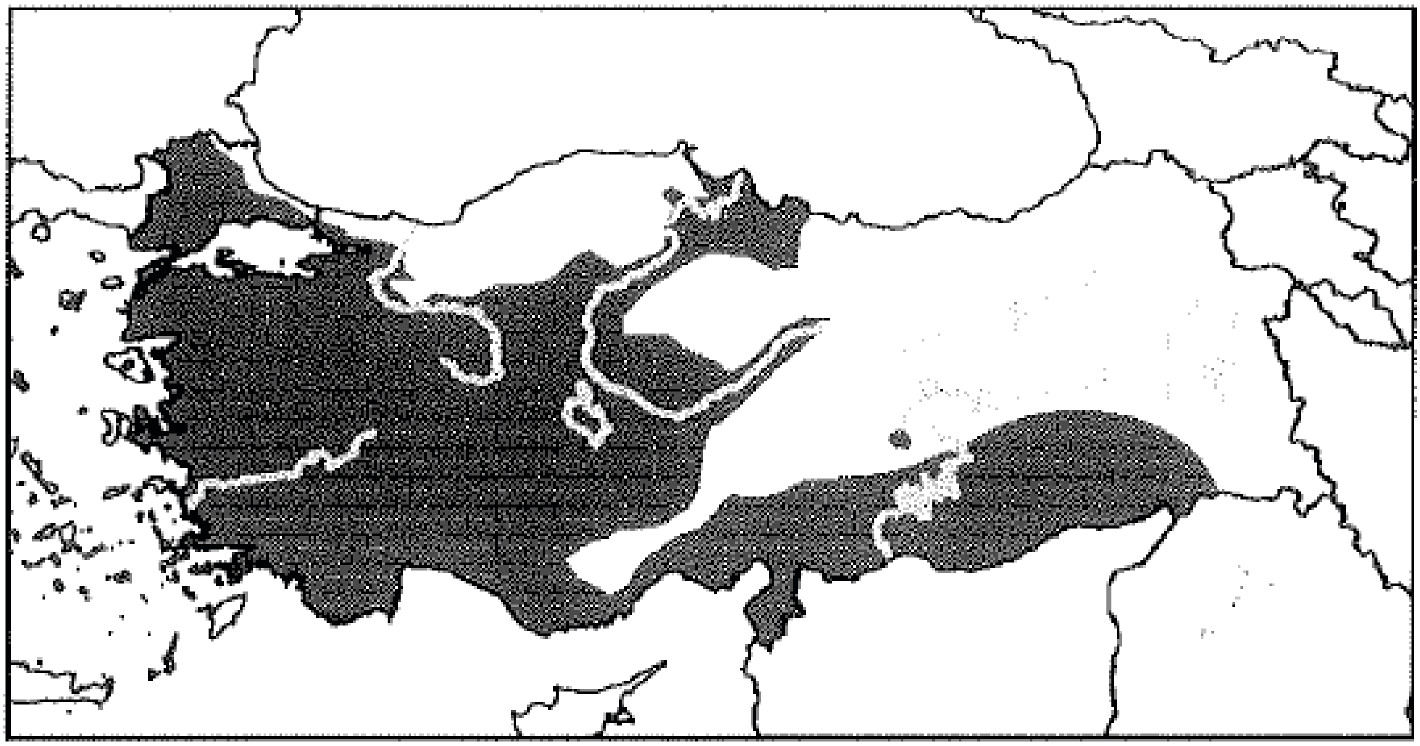

Figure 2. Distribution map of the Barn Owl in Turkey, from Kirwan et al. (2008); [redrawn for clarity by EG].

Jan 2003. The list of wildlife animals is given in Annex I of this law, while Annex III gives the list of wild animal under protection. The Annex lists have been published by the Ministry of Forestry and Water Affairs. This law is akin to species and habitat protections extended in most other countries. As well, Turkey is a signatory country to the Bern Convention.

Systematics and Morphology

The species of Barn Owl occurring in Turkey has long been recognized as *Tyto alba.* Based on morphology, earlier works have suggested that there were from one to three subspecies occurring in the country (e.g., *T.a.alba*, *T.a. erlangeri* and possibly *T.a. guttata*) (Dunn et al. 1982; Cramp et al. 1985; Kasparek 1986; Shawyer 1998; del Hoyo et al. 1999; Weick 2006:15-18). High geographical variation in plumage and body size cast doubt on the subspecific status of many subspecies (Roulin et al. 2009) as confirmed by recent molecular studies (König & Weick 2008; Nijman and Aliabadian 2013).

At the global scale, recent phylogenetic work by Aliabadian et al. (2016) reported there to be three wide-ranging barn owl species (*Tyto alba*, *T. furcata,* and *T. javanica*), along with a potential fourth species (*T. sumbaensis*). Their work highlighted the Common Barn Owl (*T. alba*) clade existing from Afrotropical and Palearctic Region at least as far east as eastern Iran, and including four subspecies: *T. a. erlangeri, T. a. alba, T. a. guttata* and *T. a. affinis.* Unfortunately, due to sampling gaps, it appears that no Barn Owls from Turkey have thus far been involved in any genetic assessments. As of 1 Dec 2017, there were no Barn Owl data from Turkey in Genbank (Vera Uta, pers. comm.).

The online Handbook of Birds of the World (Bruce et al. 2017) offers the following text pertinent to Barn Owl taxa that may have distribution in Turkey: *Considerable variation in size and color may be more individual than geographical in many continental and some island regions, with possibly expanding zones of intergradation, particularly in Europe.*

T. a. alba (Scopoli, 1769) – Western Barn Owl - W & S Europe (including Balearic Is and Sicily) to N Turkey; also W Canary Is (Tenerife, Gran Canaria, El Hierro), and N Africa from Morocco to Egypt (except Sinai), S to N Mauritania, S Algeria, Niger (Aïr Massif) and NE Sudan.

T. a. guttata (C.L. Brehm, 1831) – C Europe E to Latvia, Lithuania and Ukraine, and SE to Albania, Macedonia, Romania and NE Greece.

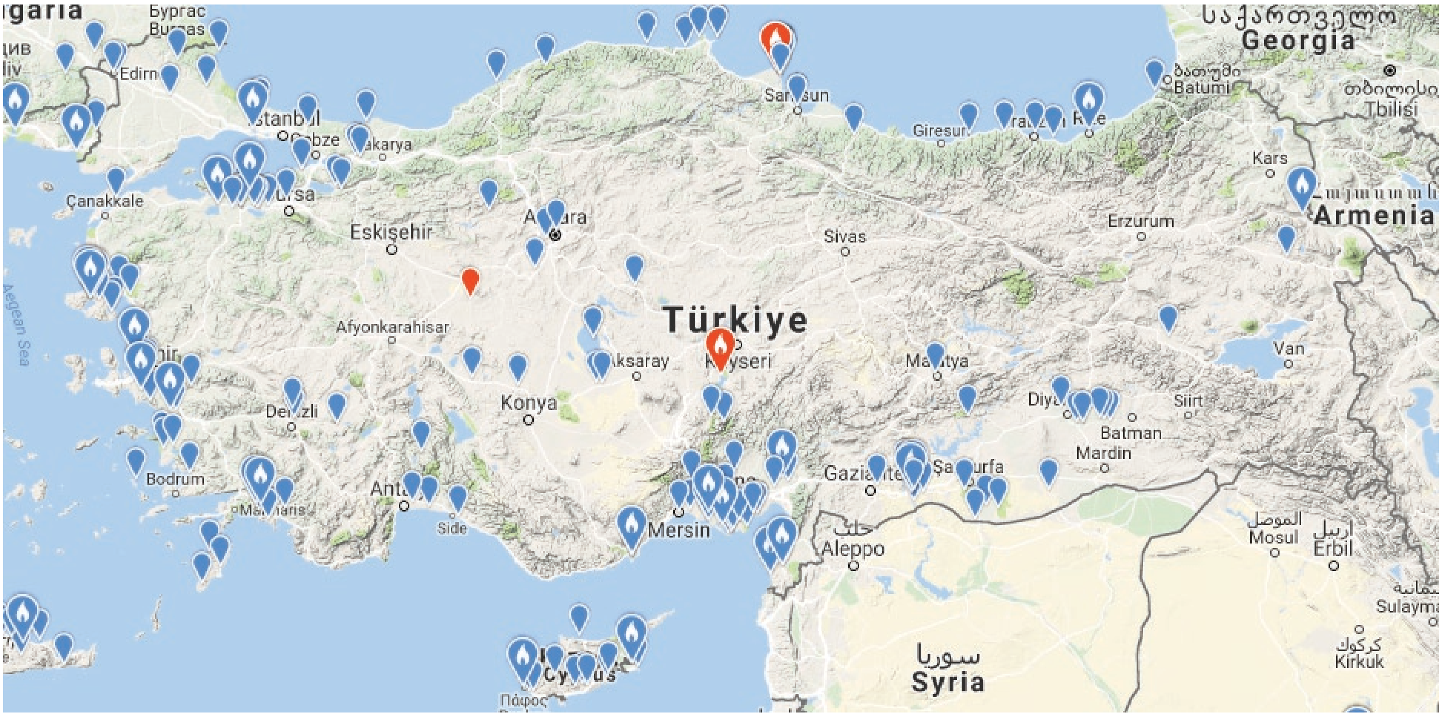

Figure 3. Distribution of the Barn owl in Turkey, based on E-bird observational records from 2002-2017 (as of 17 Nov 2017).

T. a. erlangeri (W.L. Sclater, 1921) – Crete and smaller S Greek islands, Cyprus and patchily from Syria E to SW Iran and S to NE Egypt (Sinai) and S Arabian Peninsula.

At this point, stronger details of plumage patterns (e.g., Fig 1), distribution, and genetics will be needed to sort out the Barn Owl subspecies issue for Turkey.

Distribution and Movements

Knowledge about the distribution of Barn Owls in Turkey has come slowly. General maps of Barn Owl distribution including Turkey can be found in Dunn et al. 1982:25; Cramp et al. 1985:435; Taylor 1994:12; Shawyer 1998:2; del Hoyo et al. 1999:71; König and Weick 2008:64; and Mikkola 2014:80. A map of Barn Owl distribution, specific to Turkey, is found in Kirwan et al. (2008) and Figure 2.

Important early maps showing observational records of Barn Owls in Turkey come from Kasparek (1986:48) and Kumerloeve (1986:265). Additional records and insights about the owl have been made at a number of locations in Turkey between 1986 and 2017 (van den Have et al. 1988; Kasparek 1992; van den Berk 1994; Hustings & van Dijk 1994; Kirwan & Martins 1994; OST 1969, 1972, 1975, 1978). eBird is an online datasystem for recording bird observations by recreational and professional bird watchers. eBird provides rich data sources for basic information on bird abundance and distribution at a variety of spatial and temporal scales. A map showing eBird locations of Barn Owls in Turkey during the period 2002-2017 (Fig. 3) highlights a growing number of location-specific Barn Owl observations in the country.

In Turkey, Barn Owls are more common in coastal areas than in the interior regions of the country. This is presumably due to the interplay of topography, temperature, moisture, and habitat conditions (for topography, temperature and precipitation isopleths, see Deniz et al. 2011). A shaded height and relief map of Turkey is shown in Figure 4 (www.ginkomaps.com). A general review of the overlay of the various published maps, eBird data, and shaded relief highlights the elevational relationship in the owls' distribution in Turkey, with the species' being typically found at lower elevations.

With the exception of Armenia, Barn Owls are found in all countries immediately adjacent to Turkey. Distributional maps and records of Barn Owls in these countries can be found in the following sources: IRAN: Osaei et al. 2007, Ashoori et al. 2011; SYRIA: Shehab and Johnson 2009; GEORGIA: Gálvez et al. 2005; GREECE: Bauer et al 1969; Handrinos, G. and Akriotis,

Figure 4. Shaded height and relief map of Turkey (GinkoMaps).

T. 1997; BULGARIA: Iankov, P. (ed.) 2007; Barn Owl data from Greece and Bulgaria can also be found on The EBCC Atlas of European Breeding Birds (Hagemeijer & Blair, 1997); IRAQ: ________; ARMENIA: (no Barn Owl records).

Although Barn Owls are considered as being a resident (rather than migratory) species, there is yet scant evidence on this topic from Turkey. One of us (EG) has been able to follow a Barn Owl nest site near Denizli during the years 2014-2017. Barn Owls have nested (or been present) at this site in all four of these years (E. Göçer and E. Kızılkaya unpubl. data).

Diet

The Barn Owl is a particularly good bird species for investigating the diet of a predator. The owls' pellets contain well preserved prey remains compared to other predators and owls. Owl pellet work is one of the ways to quickly record small mammal species in a region. While there are significant Barn Owl diet studies available, spanning 150+ years (e.g., Roulin and Dubey 2012, Roulin 2016), there are relatively few studies from Turkey. But, interest in the diets of owls, in small mammal distribution, and biodiversity generally have resulted in more studies in the last 10-15 years. We have included diet analysis for Barn Owls in Table 1. Not all projects reflect data solely from Barn Owls - as some studies included pellets derived from other owl species - in this case, we have not shown the results as diets specifically associated with the Barn Owl could not be identified.

Discussion

There is still much to learn about the Barn Owl in Turkey. While diet studies are helpful, and Barn Owl pellets are relatively easy to collect and analyze, the general diet of the Barn Owl is very well known around its distribution. Still, we recognize that there is the potential to learn more about the species and distributions of small mammals through the study of Barn Owl pellets in Turkey. We encourage surveys for locating owls and owl nests, and the ringing of owls to better understanding of their dispersal, movements and demography. Important advances in the subspecies determinations for Turkey and the region can come from some genetic work. Much work around the range of this owl is done with nest boxes, and while important, finding nest sites in natural cavities would offer special insights into the habitat use and ecology of this species. The provision of nest boxes has been demonstrated to help in agricultural regions where the control of rodent pests is an issue, and Turkey would benefit both from this and the associated educational benefits of such programs.

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Table 1. Barn Owl (Tyto alba) diet studies conducted in Turkey.

Brinkmann et al. (1990)	House mice (*Mus* sp.) and voles (*Microtus* sp.) formed 81.2% of the Barn Owl diet at the Menderes delta, Turkey.
Çolak (2007)	A total 309 pellets from *Tyto alba* and *Athene noctua* owls were collected from the Kilis and Şanlıurfa provinces during 2004-2007. A total of 390 individual prey items were recorded.
Hoppe (1986)	Barn Owl diet from 60 pellets collected at Magaracik, Hatay-Samandag region, southwestern Turkey. These pellets included 216 bones/remains of and 13 species of mammals, bird and insects. Mammalia 23.6 % *Crocidura russula* 0.5 % *gen. sp. Insectivora* 0.9 % *Rattus sp.* 2.8 % *Cricetulus migratorius* 42.2 % *Mus aff. musculus* Aves 1.8 % Turdidae 0.5 % Hirundinidae 19.9 % Passeridae *(Passer domesticus)* 0.5 % Paridae 0.5 %Pycnonotidae (*Pycnonotus xanthopygos*) Insecta 5.1 % Gryllidae (*Gryllotalpa gryllotalpa*) 0.9 % other Gryllidae 0.9 % Sphingidae 0.5 % Acrididae

Kasperek (1988)	House mice (*Mus* sp.) and White-toothed Shrews (*Crocidura* sp), formed 83.7% of the Barn Owl diet in the Bafa Lake area.
Kaya and Coskun (2014)	A total of 96 pellets belonging to *Athene noctua*, *Tyto alba* and *Bubo bubo* were collected from a site in Nevşehir city. Pellet contents were analyzed, but not separated by owl species.
Nadachowski et al. (1990)	This report given details on mammal and bat species collected from Turkey, Syria, Lebanon, Israel, Cyprus, and Iraq that were stored in Polish collections. Data on 14 mammal and 2 bat taxa were collected from 19 locations in Turkey. While many of the mammals denoted in this report were derived from "owl pellets" the authors do not make specific mention of which owl species were involved. It can be assumed that all or the majority of the pellets in the Nadachowski et al. paper came from *Tyto alba*, as Barn Owls were noted as their source by Obuch and Benda (2009).
Nedyalkov and Boev (2016)	The authors describe small mammal and birds taken by Barn Owls and Tawny Owls (*Strix aluco*) near the Kilbasan village and surroundings (37.3206° N, 33.1871° E, 1070 m asl), Karaman province. Pellet analysis results were separated by owl species. A total of 32 Barn Owl prey items were from 8 species of small mammals and a small passerine. <u>96.9% Small mammals:</u> 3.1% *Suncus etruscus* 15.6% *Crocidura suaveolens* 18.8% *Microtus c f levis* 3.1% *Microtus c f guentheri* 3.1% *Mesocricetus brandti* 12.5% *Cricetulus migratorius* 3.1% *Meriones tristrami* 37.5% *Mus macedonicus* <u>3.1% Aves:</u> 3.1% *Anthus sp*
Niethammer (1989)	House Mice (*Mus* sp.) and White-toothed Shrews (*Crocidura* sp) formed 84.4% of the Barn Owl diet in the Aydin (Didim-Milet) area of Turkey.
Obuch and Benda (2009)	The composition of the Barn Owl diet was analyzed from pellets collected in several regions of the Eastern Mediterranean. In total, 27 samples from 21 sites in S Italy, S Greece (incl. Crete), S Turkey, NW Syria, SW Lebanon, N Israel, and N Egypt were examined. For Turkey, the pellet collection site was at Deveciuşaği, near Adana, S Turkey, under trees, 27 Oct 1991, 36° 44' N, 35° 37' E. The combined Barn Owl diet from the Levantine parts of Turkey and Syria (reflecting a combined total of 2933 prey individuals) was: 89.7% mammals 9.38% birds 0.65% amphibians/reptiles 0.27% invertebrates

Current state and distribution of the Barn Owl *Tyto alba* (Scopoli, 1769) in Ukraine

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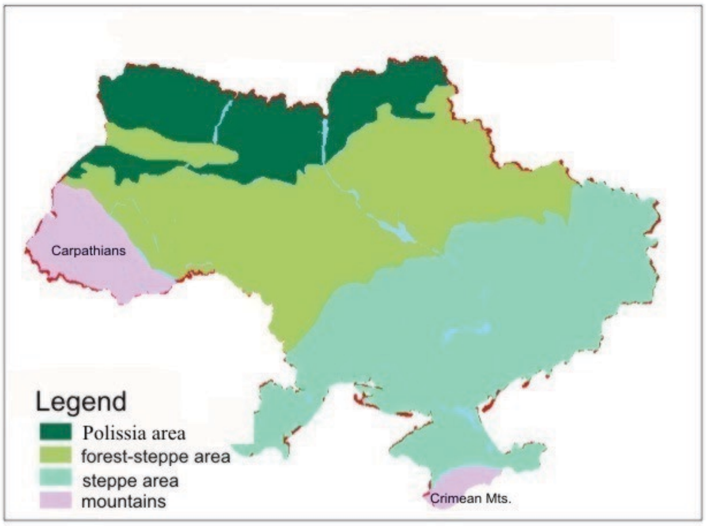
e-mail: atbashta@gmail.com) Keywords: *Tyto alba*, distribution area, current state, Ukraine

Citation: Bashta Andriy-Taras (2018). Current state and distribution of the Barn Owl *Tyto alba* (Scopoli, 1769) in Ukraine
Ela Journal of Forestry and Wildlife
Vol. 7(3-4): 507-512

Date of Publication:
30 December 2018

ISSN 2319-4361



Abstract:

The Barn owl *Tytro alba* (Scopoli, 1769) is poorly studied in Ukraine. This paper reviews its historic breeding distribution and current state. The Barn owl was known as breeding species in the eastern and central parts of Ukraine (forest-steppe part) at the beginning of XX century. Till 80's of the last century, the eastern boundary of the breeding distribution area of the Barn owl has shifted substantially to the west in Ukraine. The distribution area and breeding density of the species decreased dramatically. Comparisons reveal a substantial area of extirpation in all the country with a small, remnant population in the Trans-Carpathian region, the Crimean peninsula and Black Sea coastal region. Reduction of nesting places with the restoration of post-war houses was one of the main reasons of the species population decreasing. Other negative factors caused a decreasing of the Barn owl population were changes in the traditions of land use in private plots, growth of the private building density per unit area, use of new technologies of private household construction, especially the use of new building materials for the roof, sealing of walls. It can also be due to the owls taken away from natural habitats for use by street photographers, as well as the death on the power lines. Because of strong negative population dynamics, the Barn owl is included to the Red Data Book of Ukraine (2009) as a "disappearing" species.

Introduction

The Barn owl *Tytro alba* (Scopoli, 1769) still remains one of the poorly studied species in Ukraine, probably due to its secretive lifestyle and low numbers as well as restricted distribution area in the country.

Supposedly, two subspecies of the Barn owl occur at the territory of Ukraine. *Tyto alba guttata* (Brehm, CL, 1831) in the territory of Ukraine (Charlemagne 1938; Strautman 1954). *Tyto alba alba* (Scopoli 1769) appeared sometimes in the south-eastern part of Ukraine (probably originating from captivity) (Koshelev and Balashkov 2002; Petrovich and Redinov 2010) and Transcarpathian region.

The purpose of our work is to ascertain the current state and the distribution area of the Barn owl at the territory of Ukraine.

Materials and Methods

• ***Area***

Ukraine (603,628 square km) is situated in the eastern part of Europe. It lies between latitudes 44° and 53° N, and longitudes 22° and 41° E (fig.1).

The landscape of Ukraine consists mostly of fertile plains (or steppes) and plateaus, crossed by rivers such as the Dnipro, Siverskyi Donets, Dnister, and the Southern Bug as they flow south into the Black Sea and the smaller Sea of Azov. To the southwest, the delta of the Danube forms the border with Romania. Ukraine's various regions have diverse geographic features ranging from the highlands to the lowlands.

Broadleaved forests (incl. beech stands) of Central Europe, forests (incl. oak woods) of the forest-steppe areas of eastern Europe, mixed coniferous-broadleaved forests of northern Europe and meadow-steppe vegetation of southern areas as well as agricultural areas are represented here.

The country's only mountains are the Carpathian Mountains in the west, of which the highest is the Hoverla Mt. at 2,061 meters, and the Crimean Mountains on Crimean peninsula, in the extreme south along the coast. The Ukrainian Carpathians make up about 10% of the whole Carpathian Mts. However, Ukraine also has a number of highland regions such as the Volyn-Podillia Upland (in the west) and the Near-Dnipro Upland (on the right bank of Dnipro). Near the Sea of Azov can be found the Donets Ridge and the Near Azov Upland. The snowmelt from the mountains feeds the rivers, and natural changes in altitude form sudden drops in elevation and give rise to waterfalls. In the northern part of Ukraine lie the Prypiat' Marshes (Polissia), which are crossed by numerous river valleys (Ukraine... 2017).

• ***Surveys***

Broadcast surveys, which use playback recordings, usually of territorial or courtship have been used to locate and survey of the Barn owl and delineate its territories (Bunn et al. 2010; Shawyer 2011).

In the places, where the nests are inaccessible to the survey worker or where the classic signs of nesting had not previously been revealed outside the confines of the nest itself, we provided observational surveys.

Field surveys were focused on the detection and interpretation of the characteristic field signs provided by this bird. Surveys were undertaken during daylight hours.

Roost sites are often strewn with pellets, droppings, and feathers, the areas around and beneath active breeding sites. It was one more method for the ascertaining of the Barn owls breeding place.

Results and discussion

1. Distribution, population evaluation, trends

1.1. Forest zone (Polissia area)

The Barn owl was distributed predominantly in the border areas with the forest-steppe zone in the region of Polissya (northern Ukraine) in the 20-30's of the twentieth century (Peklo 1995). Later, only very few records of breeding were known in the Eastern and Central Polissia.

1.2. Forest-steppe zone

The Barn owl was known as breeding species in the eastern and central parts of Ukraine (forest-steppe part) in the past (Zarudny 1892; Orlov 1948). From the middle of the 20th century, the observation originated from the center of Ukraine - Kyiv, Cherkassy and Poltava regions, where its nests were found mostly in churches and belfries or in tree hollows (Pidoplichko 1963). Today there is not enough reliable data on the current distribution here. Only some records are known mainly in the eastern and south-eastern part of Ukraine (Burakov and Sulyk 2000; Koshelev and Belashkov 2002) and rarely - in central Ukraine (Kotsiuruba and Strigunov 2003; Syzhko 2007).)

In the mainland of Ukraine, the Barn owl was considered to be breeding species due to nest findings in different settlements (Portenko 1928; Pidoplichko 1932), where the eastern limit of the species range was likely to pass in that time.

Dead specimens found have been the majority of records during harsh winters, what was recorded both in the south (Roman et al. 2008; Petrovich and Redinov 2010) and in central Ukraine (Kotsiuruba and Strigunov 2003).)

Until the middle of XX century the Barn owl was a common breeding species noted in many settlements in the western Ukraine (Khranevych 1925-1926; Kistyakivsky 1950; Strautman 1954; Tatarynov 1973), especially in the Transcarpathian plain and Podolian plateau (Khranevych 1929), and it breed in church bells, attics and in abandoned houses. It was observed most often just in the post-war years and occupied the building ruins in cities. In the second half of the last century, the number of species began to decrease rapidly (Tatarynov 1973). The process of disappearance was caused by the reconstruction of cities. Currently it is a rare breeding species. E.g., the Barn owl population is estimated in 2-5 pairs in the Lviv region (Bashta 2006).

1.3. Crimean peninsula and steppe zone

In the Crimea only one observation of the Barn owl was known for a long time in the south of the peninsula (Irby 1857). The next observation was after 130 years. The bird was captured in autumn of 1989 (Domashevsky 1993). The question arises about the origin of these birds. The majority of them were found in the beginning in the plain part of Crimea in the area of two villages, Krasnoperekopsk and Petrovka (Krasnogvardeysky district) (Vetrov et al. 2008). There is a significant possibility that they escaped from captivity, since there are zoos, including birds tour to the Crimea with mobile "animal theatre".

From that period, the Barn owl began to be observed regularly in the south of Ukraine. In recent years, it has been registered in the Crimea, including the southern part both in the autumn-winter (Domashevsky 1993; Appak 2001) and breeding periods (Prokopenko and Beskaravayny 2009).

Thus, today the Barn owl is a rare but rather widespread breeding and, probably, sedentary species in the Crimea. It inhabits only anthropogenic habitats in the breeding period (Prokopenko and Beskaravayny 2009). The current number consists about 10-15 pairs here (Beskaravayny 2015). Probably, there is an increase in the distribution area of the breeding population of the species on the peninsula and on the mainland Ukraine (Yakovlev and Zhmud 2011; Arkhipov 2008).

1.4. The Ukrainian Carpathian Mts. and Trans-Carpathian lowland

In the past, the Barn owl was distributed here only in the valleys of the rivers, and settles in settlements, namely in church bells, attics and various abandoned buildings in the Carpathians. It was recorded in villages along the valley of the Latoritsa, Borzhava, Teresva rivers, deep in the mountain valleys at an altitude of 300-400 m (Strautman 1954).

In the north-western macroslope of the Carpathians (and Precarpathian area) in middle of the twentieth century the Barn owl was found mainly in the plain part of Chernivtsi region (Klitin 1959; Shnarevich et al. 1959; Tatarynov 1969).

Nowadays in all the western Ukraine, the Barn owl breeding was noted mainly in Transcarpathia (Bashta 2009, 2013). In other parts of the western Ukraine it is mostly a rare vagrant (Bokotey 1995; Novak 2003; Bashta 2006; Kapeliukh 2008, etc.).

The Trans-Carpathian lowland is a continuation of the Hungarian Plain, and the Barn owl of Trans-Carpathia is probably the eastern part of this population. Approximately 20 pairs are breeding in Berehove district (adjacent area to the border with Hungary) (Pokrytiuk and Lugovoy 2009) with density 3,15 pairs/100 km. The two sub-species *T.a.alba* and *T.a.guttata* were found here. Hybrids between these subspecies were also noted.

2. Migrations

All known records of ringed birds (n=12) are obtained from specimens, ringed at a young age and found in the first year of life. Therefore, it can be assumed that adult the Barn owl are sedentary, while young individuals perform disperse routine (Zubkov 2005). Four owls moved within their nesting range at the distance of 21 to 101 km. These birds were ringed in Hungary, the Czech Republic, and Slovakia, but discovered during their first winter or spring of the next year in the Trans-Carpathian region. Other eight owls were ringed in Germany (4 inds.), the Netherlands and France (2 inds.); they were found in the different regions of Ukraine until the central part (Poluda 2012). Thus, the birds moved in the eastern direction at the distance of 791 to 2351 km.

3. Breeding habitats

At the beginning of the twentieth century, it occupied settlements and old oak forests (Portenko 1928; Khranevych 1929). In Transcarpathia, it also occurred mainly in lowlands, in forest glades (Hrabar 1931).Nowadays, settlements (wooden and stone buildings), the cultural landscape of river valleys are the most preferred breeding habitats of the Barn owl. In the urban landscape it prefers old multi-story building in the breeding period. The breeding in the hollow trees was not noted for a long time. In Trans-Carpathia the nests have been also found in metal pipes and attics of high buildings for drying tobacco in this region.

4. Quantitative dynamics of the Barn Owl and its possible causes

A.Plater (1852) considered the Barn owl as common species of the territory, which belonged nowadays to the western Ukraine. In the middle of the twentieth century the Barn owl was common (Klitin 1959; Shnarevich et al. 1959) and rare bird species in south-eastern part of the Pre-Carpathia, Chernivtsi region (Klitin 1950, Tatarynov 1969). In our time, it has disappeared probably from this region. In Podillia, Precarpathia and Transcarpathia (Western Ukraine) in the middle of the twentieth century it was noted its number decreasing (Tatarynov 1973).

In the Eastern Ukraine O.Portenko (1928) noted that the Barn owl was a typical species of the bird fauna of the Dnipro-Don region (the area between the Dnipro and the Don rivers) and indicated that the Barn owl density has increased substantially only in recent years. It nested in the Kharkiv and Poltava regions (mainly in the forest-steppe zone) (Zubkov 2005). N.Gavrilenko (1924) noted the increase in the Barn owl density and it's possibly resettlement in the Poltava province (Central Ukraine).

In the 50-60s of the twentieth century the eastern border the Barn owl breeding area was situated already in the central regions of Ukraine (Voinstvensky and Kistyakivsky 1962). However, until 1970, autumn-winter observations of the Barn owls were known from the Poltava, Kharkiv, and Kherson regions (Peklo 1994).

Starting with the 80's of the last century, the eastern boundary of the breeding distribution area of the Barn owl has shifted substantially to the west in Ukraine. The Barn owl was observed at that time mainly in the north-western and western regions. At the same time a significant number decreasing has been noted (Bashta 1995).

I.Gorban (2004) supposed that the wintering population of the Barn owl consisted of 200-250 inds. in Ukraine in 1980-1989.

Reduction of nesting places with the restoration of post-war houses was one of the main reasons of the species population decreasing (Skilsky et al. 2007). Other negative factors caused a decreasing of the Barn owl population were changes in the traditions of land use in private plots, growth of the private building density per unit area, use of new technologies of private household construction, especially the use of new building materials for the roof, sealing of walls. It can also be the birds to be taken away from the nature for use by street photographers, as well as the death on the power lines. In the Transcarpathian region during the winter of 2009-2010, the following causes of deaths were recorded: 5 - frozen, 6 - found dead (1 - poisoning), 1 - shot down by car, 1 - power line.

Because strong negative population dynamics, the Barn owl is included to the Red Data Book of Ukraine (2009) as "disappearing" species.

Acknowledgement

The author is grateful sincerely to Leonid Pokrytiuk for essential help in carrying out the owl research.

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The Barn Owl *(Tyto alba)* in Slovenia: a short overview of current knowledge

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Citation: Vrezec Al (2018). The Barn Owl *(Tyto alba)* in Slovenia: a short overview of current knowledge
Ela Journal of Forestry and Wildlife
Vol. 7(3-4): 513-518

Date of Publication:
30 December 2018

ISSN 2319-4361

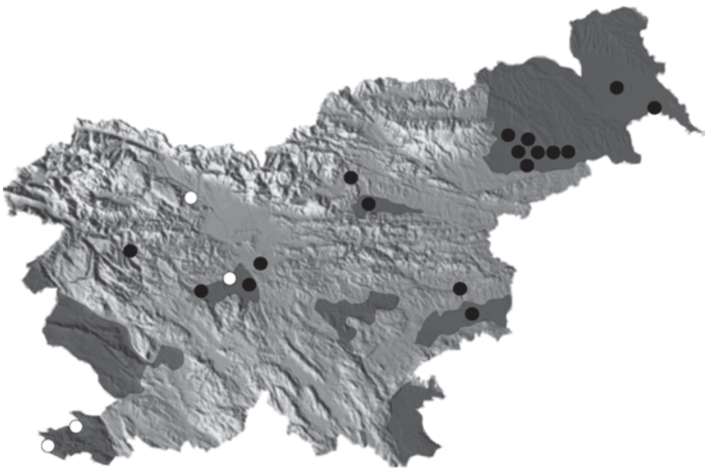

Figure 1: Altitudinal distribution of the Barn Owl *(Tyto alba)* in Slovenia. (N=91)

Key words:
Tyto alba alba, Tyto alba guttata, subspecies contact zone, altitudinal distribution, density, habitat, diet, ringing recoveries, south-central Europe, Scopoli

Abstract
The Barn Owl *(Tyto alba)* was first described in 1769 by Joannes A. Scopoli, most probably from Carniola, a duchy of the Habsburg Monarchy, which is today mainly located in Slovenia, except for a small part that is included nowadays within Italy and Croatia. The contribution is a literature review of current knowledge about the Barn Owl in Slovenia, which lies in the contact zone of two main European subspecies, brighter *T. a. alba* (confined to SW Slovenia) and darker *T. a. guttata* (confined to NE Slovenia). The lowlands in mountainous region of central Slovenia act as transitional zone between subspecies. In the contribution several natural history topics of the species are discussed based on currently available data: horizontal and altitudinal distribution, habitat, density, diet and dispersion. According to recoveries of ringed birds it seems, that birds from northern breeding ranges overwinter in Slovenia. The species is considered endangered in Slovenia, mainly because of the lack of suitable nest sites, but the species was found to be also sensitive to roadkills.

Introduction

In Europe the Barn Owl *(Tyto alba)* is a widespread owl species, lacking in Northern Europe and in the areas of high mountains of Alps, Dinaric Alps and Carpathians at the south. Montane regions are thought to separate two main subspecies recognized at European mainland, brighter *Tyto alba alba* and darker *Tyto alba guttata* (Osieck & Shawyer 1997). The mountainous borderline between subspecies is met also in Slovenia, country in south-central Europe, where both subspecies breed and even interbreed (Marčeta 1991). Although the species is confined to larger lowland areas in NE and SW Slovenia, the Barn Owls can be found also in lowland patches within central montane part of the country (Geister 1995). In general, the Barn Owl is not well studied species in Slovenia, with even no population monitoring established yet, although nestboxes are used for breeding in low numbers (Vrezec 2012). However, global studies of the species actually started in Slovenia with the first scientific description of the species (Scopoli 1769).

In 1769 Joannes A. Scopoli described the Barn Owl as *Strix alba* after the specimen originated from "Ex Foro Juli" (Scopoli 1769). Hartert (1921) interpreted that as Friaul from North Italy, but more probably the type locality was in prealpine region of the Julian Alps, what could be nowadays in Slovenia or in Italy. The type specimen was preserved in Scopoli's own collection, which is now considered lost (Violani & Rovati 2010), but for which Scopoli (1769) claimed that specimens originated from all Carniola (Gregori 2008). Carniola (=Carniolia, Krain, Kranjska) was the duchy within Habsburg Monarchy (Štih et al. 2008). According to recent state borders in the region the territory of Carniola is mainly located in Slovenia, except for a small part that is included nowadays within Italy and Croatia (see details in Vrezec et al. 2017). In the period of J. A. Scopoli research activity in Carniola between 1754 and 1769 (Petkovšek 1977) the duchy was divided into five regions including northern Carniola Superior, today Gorenjska, which included the mountainous area of Julian Alps. Furthermore, Scopoli (1769) in his overview of birds of Carniola described also *Strix rufa*, owl with ferruginous body colour with brownish spots and with dark eyes, which might resemble darker Barn Owl subspecies *T. a. guttata*, but this description has been also interpreted as Tawny Owl *(Strix aluco)* (Gregori 2008). After first description, the Barn Owl was listed as a breeding bird of Slovenia throughout 19th and 20th century (Freyer 1842, Schulz 1890, Ponebšek & Ponebšek 1934, Matvejev & Vasić 1973, Geister 1995), but till recently remained understudied with only occasional finds being reported (Ponebšek 1917), and even rarely ringed with only 35 ringed Barn Owls reported for Slovenia in the period 1927-2008 (Božič I.A. 2009, Šere 2009).

The aim of this short literature overview is to present current knowledge state about the Barn Owl in Slovenia, possible species *terra typica*, with notes on species distributional patterns, habitat, diet, dispersion and future perspectives of its conservation.

Material and Methods

Slovenia (20,273 km2) is south-central European country, which is a predominantly montane with more than one-third of the surface lying above an elevation of 600 m a.s.l. (Perko and Orožen Adamič 1998). With forests covering 58% of its area, Slovenia is one of the most forested European countries (Slovenia Forest Service 2015). Larger open lowlands are situated in NE and SE part of the country, and to some extant in SW part, but in central mountainous part there are some lowlands between mountains, such as Ljubljana Marsh near city of Ljubljana.

The study was based on literature review of studies on Barn Owl in Slovenia and on existing data in major ornithological databases in Slovenia: (1) bird collection of the Slovenian Museum of Natural History established in 19th century (Vrezec and Kačar 2016), (2) database of Slovenian Bird Ringing Center, which operates from 1927 on (Gregori 2009) and (3) citizen science database of bird observations in Slovenia that is operated by BirdLife Slovenia for the purpose of preparation of New Ornithological Atlas of Breeding Birds of Slovenia.

Results and Discussion

Distribution and habitat

The Barn Owl is considered a rare breeder in Slovenia (Geister 1995) with currently estimated 60 to 120 breeding pairs. The bulk of its population is confined to lowlands (Tome 1996) at elevations between 0 in 400 m asl (Figure 1). It lives in all major lowlands in the country, except in the montane part of Slovenia where it was found breeding only on dinaric karst field Ljubljana Marsh near city of Ljubljana (Figure 2). Depending on the course of the mountain boundary between the subspecies, the Barn Owl in Slovenia was found in two population strongholds. The first is in western Slovenia (29% of Slovenian population), which is only the extreme edge of the abundant population of the bright subspecies *T. a. alba* inhabiting lowlands in Northern Italy (Rubinič 2000). The key areas for the species in this part of Slovenia are the Vipava valley (Denac et al. 2002) and Slovenian Istra (Sedmak 2000) from where the subspecies range is prolonged further south along Adriatic coastline in Croatia till Montenegro (Osieck &

Shawyer 1997). The second population core is located in the NW Slovenia (67% of Slovenian population) and represents the edge of the Pannonian-Slavonian population belonging to the darker subspecies *T. a. guttata*. The key areas for this subspecies are Drava and Ptuj fields (Šorgo 1991, Koce 2003, Božič L. 2009) and Prekmurje (Katalinič 2000, Premzl 2006, Denac & Kmecl 2014). Additional surveys in 2002 and 2008 revealed breeding pairs also south-east in Bela Krajina and Krško lowland belonging to the same *guttata* part of the population (Figure 2). The transitional zone is the Ljubljana Marsh (4% of Slovenian population), where both subspecies were found (Figure 2), but the nesting was confirmed only for darker *T. a. guttata* (Šere 1992).

The Barn Owls in Slovenia were mostly found in open cultural landscape and in the vicinity of human settlements, where it was found nesting at the attics of churches, wall niches in the castles, barns, warehouses and similar buildings (Šorgo 1991, Vrezec 1997, Katalinič 2000, Denac et al. 2002, Koce et al., 2003), although it was also found in nestboxes outside buildings (Šere 1992, Kunst 2000). During breeding it was found coexisting with some other synanthropic species of owls, such as the Little Owl *(Athene noctua)* (Denac et al. 2002, Ploj 2002), but it seems to be avoiding the Tawny Owl, which can occupy similar nest sites in the buildings (Šorgo 1991, Denac et al. 2002, Koce et al. 2003). The densities of Barn Owls in Europe are estimated to range between 2.0 to 5.0 pairs per 10 km^2, which is also highly dependent on the number of available nesting sites (Osieck & Shawyer 1997) and on the size of small mammal populations (Taylor 1994). In Slovenia, the established densities of Barn Owls are deep below the European average with 0.2 to 0.3 pairs per 10 km^2 in the Drava and Ptuj fields (Božič L. 2009). Smaller densities are characteristic for populations at the edge of species range, but on the other hand they may also result in a lack of nesting grounds due to the closing of churches and other urban breeding facilities (Koce et al. 2003) without alternative nesting sites. The strong urbanized environments do not seem to suit Barn Owls in Slovenia (Tome et al. 2013), although breeding in such areas is known from some cities in Italy and Poland (Spadea 1995, Biagioni et al. 1996, Kuźniak 1996, Bernini et al. 1998, Luniak et al. 2001).

• Diet

The diet of Barn Owl in Slovenia was quite well studied in both population core areas (NE and SW Slovenia) as well as in transitional zone in central Slovenia (Table 1). All diet studies were done by inspection of pellets that were collected at the owl breeding and roost sites, so they represent the diet over the whole year (Janžekovič 1992, Šorgo 1992, Tome 1992, Lipej 1997, Janžekovič & Ficko 2000, Sedmak 2000). Small mammals greatly predominate in the diet and other prey species, such as birds, reptiles, amphibians and insects are only occasionally taken. In NE and central Slovenia, where the dark subspecies *T. a. guttata* predominate, most of the diet was comprised by shrews (Soricidae), predominantly by Bicolored *(Crocidura leucodon)* and Common Shrew *(Sorex araneus)* in NE Slovenia (Janžekovič 1992, Šorgo 1992) and Mediterranean Water *(Neomys anomalus)*, Eurasian Water *(N. fodiens)* and Bicolored Shrew in central Slovenia (Tome 1992, Sedmak 2000). In these areas also voles (Cricetidae) were presented in high proportion of the prey, especially the Common Vole *(Microtus arvalis)*, which comprised more than 10% of prey items at Ljubljana Marsh (central Slovenia; Tome 1992, Sedmak 2000) as well as at Goričko and Drava field in NE Slovenia (Šorgo 1992, Janžekovič & Ficko 2000). On the contrary, in SW Slovenia where *T. a. alba* breeds, the Barn Owl diet was mice (Muridae) dominated with the Wood *(Apodemus sylvaticus)* and Striped Field Mouse *(A. agrarius)* being the most abundant prey (Lipej 1997, Sedmak 2000). Although the Barn Owl seems to be small mammal specialist, it can opportunistically prey the most abundantly available small mammal species in the habitat (Tome 1992). Especially in winter time, when shrews were more or less unavailable, the proportion of voles and mice increased in the Barn Owl diet also in NE Slovenia (Šorgo et al. 1994).

• Dispersion

In Slovenian Bird Ringing Scheme there was only four Barn Owls recovered so far, all originated from northern breeding sites in Austria, Hungary and Czech Republic (Božič I.A. 2009, Šere 2009, Vrezec et al. 2013). All birds were found dead during winter time between December and February indicating winter influx of birds from north, especially from *T. a. guttata*

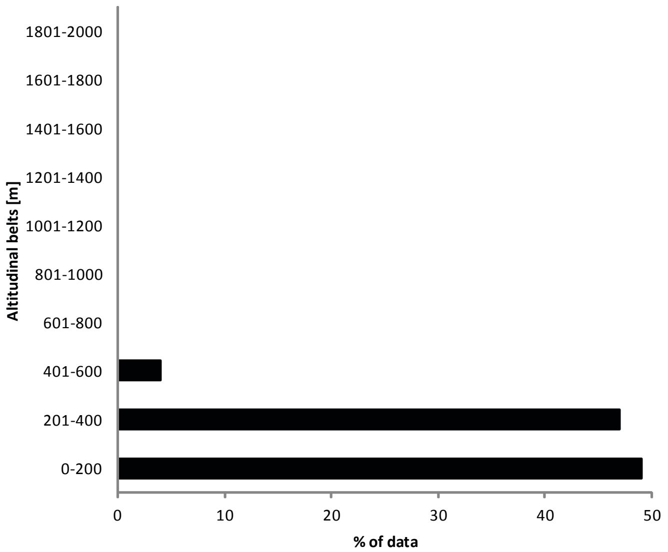

Figure 2: Breeding distribution of the Barn Owl *(Tyto alba)* in Slovenia (shadow areas) with marked finds of individuals belonging to bright *T. a. alba* (white circles) or dark *T. a. guttata* (black circles) subspecies. Data on the subspecies are based on the birds found in breeding and nonbreeding period, when owls can occur also outside known breeding areas.

breeding area. Most of the birds were young, first or second calendar year, dispersing from their breeding sites 151 to 338 km away.

• Conservation

Due to its rarity, the Barn Owl in Slovenia is considered endangered (Geister 1998), although its breeding range seems to be stable. However, the European population is declining (BirdLife International 2004) due to the loss of the hunting habitat, the loss of nesting sites and the impact of pesticides, where the loss of nesting sites has proven to be the main reason for the decline and low densities of the species (Taylor 1994). Setting up of nest boxes has proved to be a successful measure in the Barn Owl, which can significantly improve the state of the population (Taylor 1994). The nestboxes for Barn Owls in Slovenia were applied only at small scale so far (Vrezec 2012). Apart from that the Barn Owl is also a species that is more sensitive to roadkills (Rubinič 2000), also in Slovenia (Bombek 2003).

Aknowledgements

The contribution was made in preparation for the New Ornithological Atlas of Breeding Birds of Slovenia led by DOPPS-BirdLife Slovenia.

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Table 1: Overview of the Barn Owl (Tyto alba) diet (% of the number of prey items) in Slovenia according to two population core areas (NE Slovenia with T. a. guttata and SW Slovenia with T. a. alba) and transitional area in mountainous central Slovenia where both subspecies are occuring.

Region Subspecies occurrence	**NE Slovenia** ***T. a. guttata***	**central Slovenia** ***T. a. alba/guttata***	**SW Slovenia** ***T. a. alba***
Sources	Janžekovič (1992), Šorgo (1992), Janžekovič & Ficko (2000)		
	Tome (1992), Sedmak (2000)	Lipej (1997), Sedmak (2000)	
Soricidae	45.5	70.4	22.7
Talpidae	0.2	0.0	0.9
Chiroptera	0.1	0.0	0.2
Cricetidae	34.5	17.0	4.0
Muridae	16.4	11.5	69.9
Gliridae	0.1	0.0	0.0
Mamalia, total	**96.8**	**98.9**	**97.7**
Aves	2.6	0.9	1.7
Reptilia	0.0	0.0	0.2
Amphibia	0.0	0.0	0.2
Insecta	0.6	0.2	0.2
N (prey items)	2979	582	524

An overview of embryonic anomalies in failed eggs of Sparrowhawks *Accipiter nisus* and Barn Owls *Tyto alba*

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Citation: Arnold van den Burg (2018). An overview of embryonic anomalies in failed eggs of Sparrowhawks Accipiter nisus and Barn Owls *Tyto alba*
Ela Journal of Forestry and Wildlife
Vol. 7(3-4): 519-527

Date of Publication:
30 December 2018

ISSN 2319-4361

Key words:
Barn owl *Tyto alba*; Eurasian sparrowhawk *Accipiter nisus*; failed eggs; embryo anomalies; nutritional deficiencies.

Abstract

Embryonic anomalies have not been widely studied in wild birds. Data from domestic fowl have shown that embryonic abnormalities and the age at death are often indicative for the causes of egg hatching failure. Therefore, studying deceased embryos can help to understand why eggs fail. The present study reviews embryonic anomalies found in unhatched eggs of Eurasian Sparrowhawk *Accipiter nisus* L (1758) and Barn Owl *Tyto alba guttata* Brehm (1831), and investigates the developmental ages at which the embryos died. Abnormalities were detected in 70% of the embryos (N=294). Embryonic mortality was most common around day 3 of development, and these embryos showed strong signs of vitamin deficiency, especially vitamin A and B2. Abnormalities found from day 4 until day 9 show closest resemblance to dead embryos from domestic fowl that suffered amino acid imbalance. Increased mortality at days 11-12 matched the pattern found in generally micronutrient deficient poultry. Finally, embryonic mortality peaked towards the end of incubation, mainly due to malpositions of unknown cause. Because the present data suggest that food quality (measured by the quantity of particular micronutrients, especially vitamins and amino acids) is an important factor in embryo mortality, more research should be attributed to determine how nutrient deficiencies arise in wild bird populations.

Introduction

In poultry, much research has been dedicated to hatching failure, and also the pathogenesis of the avian embryo. In a book of that name, Romanoff (1972) compiles decades of research, including references from centuries ago. Embryonic malformations were extensively studied in the past, but much of this research was never followed up and this book has for long been the only résumé of embryo teratogenicity. More recently, two researchers from the Netherlands reviewed all known causes of hatching failure in poultry in a Dutch publication (Fabri and Kühne 1988). Much of the material existing in literature (N=356 publications) dates from the nineteen sixties, indicating that the topic was most intensively studied during that decade. The present study as well as the above sources were integrated in a recent practical guide into investigating egg failures in birds (Van den Burg 2017).

There seem to be few descriptions of embryonic anomalies in wild birds despite their potential importance to research into the causes of hatching failure. Especially since the occurrence of particular abnormalities and the age at which an embryo dies can be indicative of the cause of death. If the abnormalities of wild birds match those in domestic fowl, their causes may be similar too. Although there are differences between domestic fowl and wild birds, they share many biological features such as physiological and developmental pathways. Factors that cause embryonic anomalies by interfering with fundamental processes are likely to show similar effects in poultry and avian wildlife.

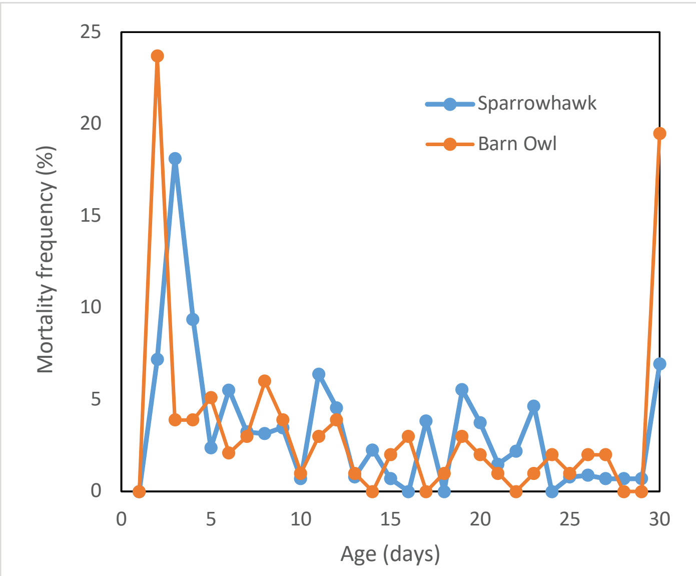


Figure 2. Embryonic mortality in Barn Owls and Sparrowhawks shows a similar pattern: a peak around day 2-3, 4% daily until day 9, and peaks at day 11-12, and shortly before hatching.

There has been great concern among conservationists about egg failure since pesticides were first shown to reduce shell quality and avian reproduction over 40 years ago (e.g. Newton and Bogan 1974). Studies of hatching failure might reveal previously unknown interactions between physiological and environmental aspects of avian population dynamics. For example, reduced egg viability in Great Tits *Parus major* was reported from forests suffering human-induced soil acidification, leading to calcium shortage in the food chain (Graveland et al. 1994). This resulted in extinctions of snails as a calcium source for laying birds and structural deficiencies in egg shells. Here, the descriptions and frequency of embryonic abnormalities in Sparrowhawks *Accipiter nisus* and Barn Owls *Tyto alba* are reported, together with the developmental age of death. Possible causes of these anomalies are discussed, in the light of literature reports of research into the domestic fowl.

Material and methods

Failed Sparrowhawk eggs were collected from nests in the southern and eastern parts of the Netherlands, and a region just across the border in Germany in the period between 1996 and 1999. Barn Owl eggs were collected throughout the Netherlands from 1997 until 1999. Eggs were opened carefully so the original orientation of a large embryo could be determined before it was lifted out of the shell. All embryos were immersed in water and examined visually for external anomalies. Small embryos were also studied under a dissection microscope (10-40x magnification). The total length and blastoderm diameter were measured for the smallest embryos. For larger ones, the diameter of the eye (the complete eye ball) was taken. Some internal measurements were taken to detect disproportional growth of one organ relative to another: ventricle length and width, height of the right liver lobe, and the length and width of the rostral lobe of the metanephros (kidney). The measurements were made with callipers (reading 1/20 mm) or through the binocular using a scaled eye-piece.

The developmental age at which the Sparrowhawk embryos had died was determined from the eye-diameter, by comparison with embryos that had died at known age. The latter originated from deserted clutches where the laying and desertion dates were known precisely. Similar 'standard embryos' were not

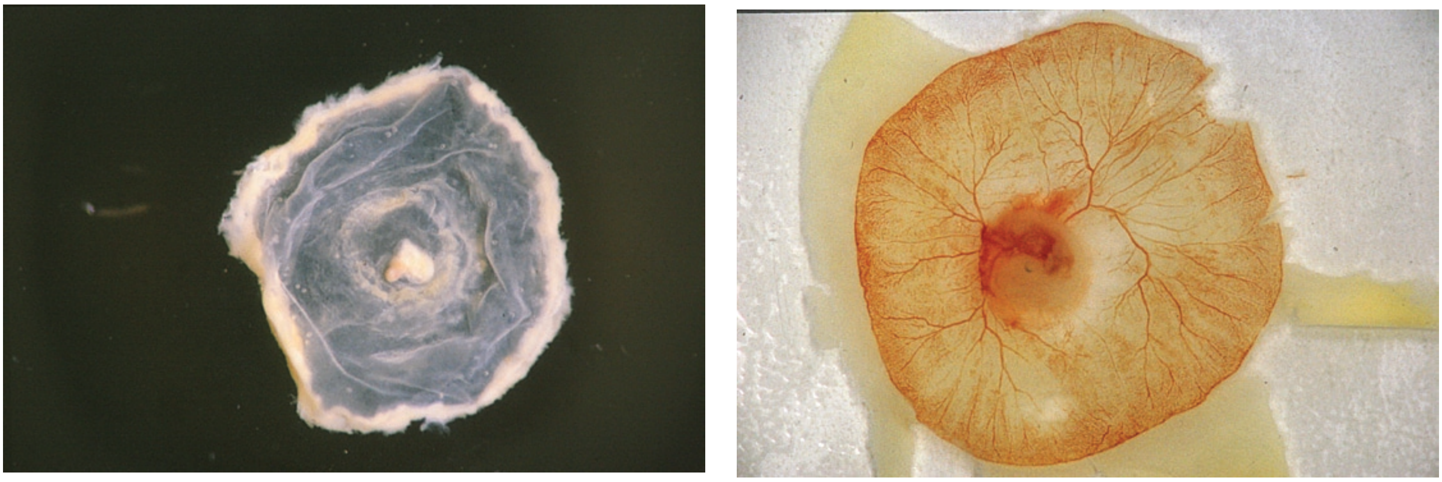
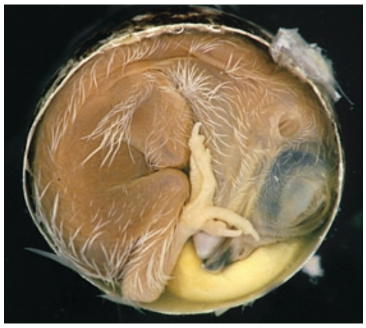


Figure 3. Examples of embryonic anomalies.
A. Anomaly 'pinhead' in the Sparrowhawk (top) showing hardly any blood vessels and the formation of a denser ring of tissue in the embryonic membranes. For comparison also a well-developing embryo is shown (Barn Owl; bottom).

B. Monomicrophtalmia of the left eye. Displayed are two sides of the same Barn Owl embryo. The bottom picture shows an abnormally small eye.



C. 'Embryo in width' malposition in a Sparrowhawk.

available for the Barn Owl. However, both species are semi-altricial (as defined by Pough et al. 1989) and the embryos show a sigmoid growth curve, in contrast to altricial birds that have an exponential growth curve (Vleck et al. 1980). Additionally, the beginning and end of the growth curve could be determined from the embryos, as well as the slope of the curve a few days before hatching. The youngest embryo showing eye pigment was assumed to be three days old, and embryos just before hatching could be recognised by the way it had folded itself inside the shell and the completed yolk absorption in the abdomen. Embryos slightly younger than these are in the process of folding, and yolk absorption is incomplete. These data showed that, like Sparrowhawks, the growth of the eyeballs of Barn Owl embryos had slowed down before hatching.

These data were used to approximate the growth curve of Barn Owl embryos. The method was first validated using the Sparrowhawk data. To do so, the function parameters that describe the S-curved shape of the growth of the Sparrowhawk eye were estimated based on the method described in Causton (1977). A limited exponential growth model was also calculated, because the average between this and the logistic equations appeared to best fit the observed data for Sparrowhawks (Fig. 1). This procedure was then repeated for the Barn Owl embryos, assuming a similar growth pattern.

To search for repeated co-occurrence of anomalies, embryos or eggs that had come from a single clutch were sorted in the format of a 'differentiated table', as is commonly used in vegetation science (Kent and Coker 1992).

Results

Abnormalities

In the Sparrowhawk, 184 eggs yielded dead embryos and 75% of these had structural or positional abnormalities. Similarly, 63% of the dead Barn Owl embryos (N=110) were found to have defects. The range of abnormalities was large; 45 different defects and malpositions were recognised (Table 1). 'Pinhead embryo' was the most common in both species.

Some embryos (N=49) showed multiple anomalies, and so contributed more than once to Table 1. In Barn Owls co-occurrence of anomalies was more frequent compared to Sparrowhawks, and also there were overlapping clusters of anomalies (Table 2). The abnormalities that typically form clusters include coelosomia, aplasia of the liver, flat head, bent extremities, (mono-) microphtalmia, exencephalia, spina bifida and lordosis. Three Sparrowhawk embryos had a wider more muscularised heart combined with the "embryo in width" malposition (Table 1).

Multiple anomalies within clutches (rather than within embryos) did not reveal any new groups. In 3 clutches (2 Sparrowhawk, 1 Barn Owl) the presence of 'pinhead' embryo co-occurred with fertilised eggs that showed no embryonic development at all. Egg fertility was assessed by the presence of sperm cells in the yolk membrane (Van den Burg 2017).

Developmental age

The relationship between mortality and developmental age was very similar in Sparrowhawk and Barn Owl embryos (Fig. 2). The pattern that emerged from both species differed from that in poultry as can be seen for the average of poultry (Romanoff 1972), in which there is a slight elevation early in development and most mortality is towards the end of incubation. Most commonly, embryos died during the first days of development, on days 2 and 3. The mortality rate remained elevated until day 9 and after a dip on day 10, there was an upsurge again on days 11 and 12. On days 19 and 20, both species again showed elevated mortality, with a further peak at the end of embryonic development.

The 'pinhead' abnormality is the major contributor to early mortality on days 2 and 3. Other abnormalities during the first week of development were predominantly components of the overlapping clusters (Table 2) observed in the Barn Owl. Beak defects and heart deformities were more common in embryos that died during the second week. Celosomia, kidney underdevelopment and aberrant positioning of embryos in the width of the egg occurred most frequently around day 20. Finally, embryos dying just before hatching usually failed to attain the correct position within the egg or had heart deformities. Embryos that died at the end of incubation could not be grouped into age classes on the basis of eye diameter, and hence the peak at day 30 is an overestimate. Mortality should probably be spread across a 5 day period after day 30 as the eggs should hatch around day 34 in both species.

Mortality of Sparrowhawk embryos that did not show obvious abnormalities did not peak at any particular developmental age. In Barn Owls, embryonic mortality among the embryos without anomalies peaked at days 2 and 30.

Discussion

Some embryos were too decayed to determine whether or not they were abnormal, but they are included in the totals because some abnormalities could be recognised even though the embryo was decayed. Special care was taken to ensure that post-mortem effects, such as haemorrhage due to tissue deterioration, were excluded. However, this caution might have resulted in the omission of some 'true' abnormalities. Consequently, the record of abnormal embryos must be considered a minimum.

In poultry, the embryo abnormality 'pinhead' has been linked to eggs deficient in vitamin A (Thompson et al. 1965) and B2 (riboflavin; Romanoff and Bauernfeind 1942). Because these vitamins occupy key positions in fundamental metabolic pathways and growth (Engbersen and De Groot 1992), it might be expected that similar effects of their deficiency might be found in wild birds. Certainly, vitamin B2 deficiency symptoms described for domestic fowl, such as deterioration of blood vessels and the formation of a dense ring of tissue in the embryonic membranes, were frequently paralleled among the Barn Owl and Sparrowhawk embryos.

Deficiency of either vitamin can cause mortality at a very early stage, depending on its severity. Mortality can occur before the embryos are detectable in the egg, and the occurrence of fertilised eggs that lack an embryo in the same clutches that show 'pinhead' may support this. One deserted Barn Owl clutch also revealed very weak yolk pigmentation, which can be an indication of vitamin A deficiency (Romanoff and Romanoff 1949). The eggs from this clutch did not show embryonic development, despite being fertilised. Both vitamins cause the production of poor quality eggs, before egg production ceases altogether.

The likelihood of such vitamin deficiencies occurring in the wild will depend upon food availability, its vitamin concentration, and individual efficiency of vitamin transfer. As vitamin B2 cannot be stored by vertebrates (Romanoff and Romanoff 1949, Engbersen and De Groot 1992), hens that receive a diet deficient in B2 soon start to produce fewer (and unviable) eggs (Squires and Naber 1993a). Vitamin A can be stored in the liver, and reduced egg viability is not seen until a longer period of deficiency, compared with vitamin B2 (Squires and Naber 1993b). Thus, B2 deficiency is more likely than vitamin A deficiency.

In the Sparrowhawk, several cases were observed that link 'pinhead' with nutrient deficiency (Van den Burg 2000). This condition was found repeatedly in pale pigmented eggs that were known to be the last in a laying sequence - either the last of a clutch or before an egg laying break. Also, a female that was forced to produce 9 eggs (typically, Sparrowhawks produce 4-5 eggs) due to partial predation of her clutch, suffered egg hatching failures in the last four, showing 'pinhead'. Interestingly, this female maintained a high body weight throughout, indicating that the anomaly may be caused by depletion of a micro-nutrient, and not by a general shortage of food. At two other nests where the abnormality occurred, the females were in poor condition as measured by their low body weight.

The group of anomalies that showed signs of association in this study were similar to abnormalities of chicken embryos that have been linked with amino acid deficiency or imbalance (i.e. not available in appropriate proportions). Romanoff (1972) lists the following as being caused by a faulty amino acid composition: size reduction of the beak, celosomia, ectopic viscera, twisted and shortened limbs, lordosis, shortened body, eye degeneration, and open spine. Depending on the exact amino acid and the severity of the deficiency, several of these anomalies may become apparent in a single embryo. Such deficiencies may occur in wild birds if the female does not have sufficient vitellogenins at her disposal. These are female-derived proteins that form the primary source of amino acids for the embryo (White 1991). Such deficiencies may especially occur in the last laid eggs as stored vitellogenins may have been used in earlier eggs, and females have to fully rely on dietary amino acid intake to produce new vitellogenins. The amino acid composition of the food may not be similar to the requirements for egg production (Houston et al. 1995, Selman and Houston 1996).

Another anomaly that has been described in poultry is the malposition 'embryo in width'. This abnormal posture of the embryo is caused by failure to turn the egg during the first few days of incubation (Fabri and Kühne 1988). In these cases, the amnion sticks to the shell membranes, making it impossible for the embryo to later rotate towards a longitudinal position within the egg. In this study, it was only found in Sparrowhawks. In contrast to Barn Owls that start incubating and caring for the eggs from the first egg (Taylor 1994), Sparrowhawks may leave the eggs unattended and incubation is postponed until shortly before clutch completion (Newton 1986). These differences in brooding behaviour match the observation that anomalies due to insufficient egg turning occur in Sparrowhawks only.

An explanation for the possible relationship between egg turning and heart anomalies in 'stuck embryos' is not available in current literature. However, failure to turn the eggs also disturbs the normal growth of the embryonic membranes and the physiological mechanisms that govern the redistribution of water inside the egg (Tullet and Deeming 1987, Deeming 1991). This causes a reduced respiratory capacity of the embryonic membranes (Tazawa 1980). Embryos possibly try to compensate for this loss of oxygen transfer by increasing cardiac output, which may cause the observed heart abnormalities.

Other malpositions have been described in poultry, but their causes can be very diverse. Brooding temperature (too cold or too warm) is one of the most important factors affecting the position of the poultry embryo (Fabri and Kühne 1988). Other temperature effects are celosomia (too warm shortly before hatching) or early hatching (too cold) (Fabri and Kühne 1988).

The age at which poultry embryos die is associated with particular abnormalities (Romanoff 1972). Vitamin deficiencies cause mortality at days 2-3. From day 4 until day 9, embryos showed mainly signs of amino acid deficiency. The anomalies found at day 11-12 are not indicative of a single cause, but in poultry a peak around this age is a sign of nutritional deficiency, such as mild vitamin B2 deficiency (Romanoff 1972). At this age, many organs that developed during the first 10 days of embryonic growth become functional, revealing shortcomings in organ development and physiology, which may be due to micronutrient deficiency. At this age, the kidney system also switches from the mesonephros to the metanephros (Romanoff 1960, Romanoff 1972). Failure to do so apparently result in kidney underdevelopment, with mortality at days 19-20.

In the Barn Owl, mortality of embryos seemingly free from structural abnormalities peaked at day 2 and 30. Early failures without anomalies can be caused if eggs are newly laid in nest boxes where chicks from an earlier brood are still present. These eggs are incubated less efficiently and may be deserted by the female, due to disturbance by the fledglings roosting in the nest box (*personal observation*). Embryos without anomalies that died shortly before hatching may also be the result of inadequate brooding. There can be an age difference of more than two weeks between the oldest and the youngest chicks within a Barn Owl brood, and brooding of the last laid eggs may be impaired by the larger chicks.

Many toxins, of which dioxins and PCB's are perhaps the most important, can also cause mortality at a late stage, without leading to structural anomalies (Fabri and Kühne 1988). PCB's are present in the environment, and their levels can differ considerably between locations (Newton et al. 1999; Wegner 1999). However, in Sparrowhawks, no relationship was found between embryonic mortality and PCB levels of unhatched eggs in the time-period in which the study was conducted (*pers. comm.* I. Newton).

In conclusion, the data presented here suggest that vitamin and amino acid deficiencies are major causes of embryonic mortality. As Barn Owls maximise egg production with clutch sizes over 10 eggs under good food conditions, they incur the risk of producing poor quality eggs (Van den Burg 2002a). In contrast, Sparrowhawks have a more conservative clutch size rarely exceeding 6 eggs. As female Sparrowhawks frequently fail to lay after building a nest in low grade habitat (Van den Burg 2002b), it is tempting to speculate that vitamin and amino acid shortages may hamper egg production in a similar way as reported for the domestic fowl. However, further studies are needed to investigate the production and fate of these micronutrients in ecosystems and food chains, and their influence upon avian reproduction in the wild.

Acknowledgements

I wish to thank all Sparrowhawk and Barn Owl researchers who contributed to collect the failed eggs used in this study (under licence of the Dutch Ministry of Agriculture, Nature Conservation, and Fisheries). I am also grateful to the landowners who permitted my own collection efforts and to D.T. Parkin of the University of Nottingham for his comments on an earlier version manuscript. Finally, I thank the section Experimental Zoology of the Wageningen University and Research Centre for the laboratory space and facilities that I could use to open the eggs.

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Table 1. Anomalies observed in Sparrowhawk (N=184) and Barn Owl (N=110) embryos.

anomaly	Abnormalities (N)		age	Description
	A. nisus	T. alba		
1. pinhead	59	18	2-3	Embryo underdeveloped, partly differentiated or not at all; circulatory system in the extra-mbryonic membranes degenerated
2. coelosomia (ectopic viscera)	4	7	4-10,(1x19)	Viscera not enclosed in the body wall
3. lordosis	5	7	4-6	Spine in an S-curved shape
4. microphtalmia	0	3	3-10	Smallness of both eyes
5. monomicrophtalmia	1	11	3-10	Smallness of one eye
6. anencephalia	2	0	3-6	Absence of the brain
7. anideus	5	3	-	Blastoderm without an embryo
8. anophtalmia	2	1	4-7	Absence of eyes
9 aplasia of kidney	1	0	30	Absence of one or both kidneys
10. aplasia of liver	0	5	3-4,19, 30	Absence of the liver or liver lobe
11. twins	2	1	2-4	Twinning of entire embryos on a single yolk in a single blastoderm
12. twins	2	0	30	Twins on a single yolk from a double blastoderm
13. ectopia of the stomach	1	0	33	Stomach misplaced
14. celosomia	6	0	16-22,30, 33	Hernia of the viscera
15. exencephalia	7	6	3-10, 30-33	Exposed brain
16. kyphosis	2	0	3-8	Pronounced forward curvature of the spine
17. monophtalmia	1	0	7	Absence of one eye
18. spina bifida (rachschisis)	3	4	4-10,30	Open spine
19. muscular dystrophy	2	1	18-25	Musculature underdeveloped, especially in the legs; thin legs
20. prognathism	6	9	8-16	Abnormal projection of one or both jaws; typically lower yaw hooked down- or upward
21. heart twinning	2	2	4-7,14	Partly or complete double heart
22. lower jaw twinning	0	1	30	Two completely formed lower jaws, in side by side arrangement
23. long upper jaw	3	0	12-25	Upper jaw extended and not hooked downward
24. short spine	2	2	3-5	Body shortened
25. embryo in width	11	0	18-26	Embryo curled in the width instead of the length direction of the egg
26. head over wing	2	2	33	Head over the right wing instead of under
27. head under left wing	1	1	33	Head bent towards the left instead of right
28. head between thighs	1	0	30	Head not curved further upwards, to the right wing
29. head in pointed end	2	2	33	Head in the pointed end, turned away from the air chamber
30. upper jaw absent	0	1	26	Median part of the upper jaw absent
31. flat head	2	5	4-12	Laterally flattened head

anomaly	Abnormalities (N)		age	Description
32. bent extremities	3	8	3-7,10	Wings, legs, and often the tail bent backwards
33. kidney underdeveloped	3	1	19, 26	Metanephros not full-grown; kidney functions through mesonephros
34. long neck	1	0	18	Long neck (>twice the usual size)
35. heart small	4	0	10,18	Heart small and often elongated
36. heart abnormal	14	1	6-11,16-19,30	Typically, the heart is wider than long
37. urethra stone	2	0	33	Stone in the urethra, usually in the umbilical cord, possibly blocking other transport
38. open neck	2	0	6-12	Imperfect fusion of visceral arches
39. no extremities	1	1	3-6	Limbs and wings not formed
40. no membranes	2	1	3-4	Extra-embryonic membranes (partly) absent
41. leg over head	1	2	30	Malposition
42. early hatching	0	1	30	Embryo breaks the shell prematurely (yolk sac not incorporated in abdomen)
43. large kidney	0	1	6	Large kidney
44. scoliosis	0	2	7-10	Lateral curvature of the spine
45. capped egg	1	1	33	Shell of a hatched egg covers the broad pole of an unhatched egg, which makes hatching impossible.

Table 2. Co-occurrence of anomalies in Barn Owl embryos.

Embryo nr.	Age	Anomaly number (frequency in parenthesis; N = 110)														
		2 (7)	10 (4)	31 (5)	32 (8)	4&5 (12)	15 (5)	18 (4)	3 (2)	21 (2)	24 (2)	37 (1)	40 (1)	41 (1)	45 (1)	8 (1)
1	19	1	1													
2	4	1	1							1						
3	4	1	1	1		1										
4	4	1		1	1											
5	10	1		1	1	1		1								
6	7			1	1	1										
7	5				1	1						1				
8	3				1	1										
9	6	1			1	1	1			1						
10	7	1			1		1								1	
11	5				1		1									
12	3						1				1					
13	7						1									1
14	6					1		1								
15	10					1		1								
16	7					1		1								
17	3		1			1			1							
18	5			1		1			1				1			
19	2					1					1			1		

Fate of moribund Barn Owls *(Tyto alba)* in Pune district, Maharashtra, India

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Citation: Pande Satish A., Lonkar Rahul, Pawar Rajkumar, and Pande Nivedita (2018). Fate of moribund Barn Owls *(Tyto alba)* in Pune district, Maharashtra, India
Ela Journal of Forestry and Wildlife
Vol. 7(3-4): 528-530

Date of Publication:
30 December 2018

ISSN 2319-4361

Key words:
Barn Owl, threats, fate, moribund owls, owl rescue, owl conservation.

Introduction:

Barn Owls (*Tyto alba*) are nocturnal birds of prey with a worldwide distribution between the temperate regions with an ability to use human modified habitats (Taylor 1994, Marti et al. 2005). Barn Owls nest in cavities in trees, cliffs, caves, riverbanks, well walls, church steeples, barn lofts, and nest boxes (Snow and Perrins 1998, Duncan 2003). They consume rodent species, many of which are economically important agricultural pests. Barn Owls are therefore useful agents of biological control of rodent pests and appear to be a more cost-effective alternative to chemicals by reducing the negative effects associated with rodenticides (Kan et al. 2013). Barn Owl populations are declining globally (Bruce 1999). Few publications from India describe the threats to and fate of moribund Barn Owls (Pande et al. 2005). In this paper we analyze the causes of morbidity of Barn Owls found moribund for various reasons and investigate their fate in Pune district, Maharashtra, India.

Agricultural Rodent Control Using Barn Owls: Isitprofitable?

Methods:

Between 2007 and 2018 we opportunistically examined Barn Owls that were compromised (injured, starving or prematurely fledged) at various locations in Pune district, Maharashtra, India. The owls were retrieved, examined and rehabilitated as required. Dead owls were weighed with a Pesola scale to within 1 g. Dead Barn Owls were sexed by dissecting them. Causes of Barn Owl morbidity or mortality were investigated. Barn Owl chicks that had fledged prematurely were replaced in their nests. The nests were located by the loud hissing noise produced by remaining chicks in the nests and usually confirmed by information gathered from local people.

Barn Owl nests were typically in hidden recesses in human occupied buildings. Residents disturbed by the noise made by the nesting owls blew crackers or made other loud noises to expel the owls from their nests. To mitigate this residents of buildings with owl nests, or near buildings with nests, were educated and sensitized about Barn Owls, especially regarding their positive economic role in the control of agricultural rodent pests and the need to help moribund owls in a timely manner.

Results and Discussion:

Thirty-three moribund Barn Owls were found in Pune district from 2007 to 2018, and they were compromised for the following reasons:

i) Flightless chicks prematurely fledged due to human disturbance (n=14),
ii) Unable to fly by the roadside (n=13),
iii) Road vehicle collisions (n=3),
iv) Injured and strangulated in nylon kite thread (n=1),
v) Injured due to strangulation in crop protection nylon net (n=1), and
vi) Injured due to collision with metal mesh net (n=1).

Fourteen Barn Owl chicks between 2 to 4 weeks of age had prematurely fallen out of their nests in human occupied buildings as a result of human intolerance (due to noise of chicks) and subsequent nest disturbance by humans. After examination, if the chicks were found to be uninjured they were replaced in the respective nests within 24 hours. Thirteen of the 14 rescued Barn Owl chicks survived and one died. All 13 Barn Owls that were found unable to fly and were stranded by the roadside survived after receiving first aid; low ambient temperatures (< 160C) were associated with these instances. The remaining six Barn Owls died (see above).

It is likely that low ambient temperatures reduced the activity of the Barn Owls and lead to the observed morbidity. For 17 cases reported herein (13 Barn Owls found beside roads and four premature fledglings) the lowest night ambient temperatures were between 60C and 150C (Av.+/- SD = 8.50C +/- 1.50C). Rodent activity decreases in cold weather leading to the starvation of Barn Owls (Unpublished Data, see also The Barn Owl Trust in references below). The Barn Owl is vulnerable to low temperatures (Marti and Wagner 1985) and winter weather mortality has been reported from the United States (Errington 1931, Stewart 1952, Keith 1964, Marti and Wagner 1985) and Europe (Honer 1963).

In our study, the mass of Barn Owls (n=9; six males and three females; seven adults and two juveniles) that had died ranged between 203 g to 376 g (Av.+/- SD = 302 g +/- 63.8 g). Female Barn Owls (360-425 g) are slightly heavier than males (around 330 g) (The Barn Owl Trust, see References). In our study, two male Barn Owls were emaciated (<250g), two (one male and one female) were thin (250 and 290 g, respectively), two (one male and one female) were average (272 and 310 g, respectively) and three (two males and one female) were healthy as per the criteria of The Barn Owl Trust (see References). Thus six out of nine dead Barn Owls were of less than average mass.

We interacted with people where Barn Owls were nesting in human occupied buildings to inform them about Barn Owls and the benefits of conserving them. All people we talked to agreed to tolerate the noise of the chicks until they fledged. Hence, the replacement of prematurely fledged chicks in their nests was successful. People told us that they had been either fearful of or irritated by the unknown sounds made by the chicks in the concealed Barn Owl nests in their buildings and that they had exploded crackers to get rid of the nocturnal disturbance. This led to chicks falling out of the nests prematurely. Conservation education and public outreach to address additional threats to Barn Owls from nylon kite threads, crop protection mesh and other nets, and road traffic can make a positive difference in owl conservation. We also feel that higher public sensitivity, rapid response and quick rescue can save lives of Barn Owls at risk.

Conclusions:

In the present study undertaken between 2007 and 2018 in Pune district, we investigated the fate of 33 Barn Owls found moribund due to various reasons. We found that 26 (79%) Barn Owls survived and 7 (21%) died. The morbidity or mortality of all the Barn Owls was a consequence of anthropogenic activity, human intolerance to noise of chicks nesting in human occupied buildings, low ambient temperature, and public indifference towards morbid owls. Conservation education was given to residents on all occasions where compromised Barn Owls were found. We conclude that rapid intervention and treatment can prevent mortality of morbid Barn Owls. Hence, public education and timely intervention play an important role to safeguard the Barn Owl.

Acknowledgement:

We are grateful to Mr. Jeet Singh, IFS, APCCF (RET) for allowing and facilitating our study. Research was conducted at Ela Habitat, the field station of Ela Foundation at Pingori, Purandar, Pune. We also thank all those who informed us of moribund Barn Owls over the past several years.

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Since started as a Newslwttwre in 2012.

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ISSN 2319 - 2461
Journal for Private Circulation only

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