Conservation methods and their applicability for the Swedish Barn Owl population

Bevarandemetoder och deras tillämpning i den svenska populationen av tornugglor

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Contents

1. Abstract

Despite a wide global distribution, the global population of Barn Owls has suffered a decline in recent years. In Sweden the population has been classified in literature as week and on the brink of extinction. The aim of this study was to investigate the national status of the Swedish Barn Owl population as well as the possible reasons for the limited population size. In addition the aim of this survey was to evaluate the applicability of different methods for conservation of Barn Owls in Sweden.

As of date, the Swedish population is classified as critically endangered with a limited number of breeding pairs located to the island of Gotland. There are several documented observations of Barn Owls in the province of Scania in southern Sweden, but this population is today believed to be extinct. Several factors are thought to be limiting the population, with severe winters and modernizations in agricultural trends considered to be the main ones.

To date, providing nestboxes is the single applied method for conservation in Sweden. However, the method has so far not showed any results in the population. The main reason for this is believed to be that the cold winters make Sweden unsuitable as a habitat for Barn Owls and that the population is therefore beyond saving. Further studies are necessary to evaluate the effects of other methods of conservation such as supportive feeding, captive breeding and release and habitat protection. However with the threat of winters still standing, the estimated effects of further conservation efforts in Sweden is most likely limited or nonexistent.

2. Introduction

2.1 The Barn Owl

Among all the nocturnal species of birds, the Barn Owl (*Tyto alba*) is by many accounts the most mysterious (Smitterberg, 2014). According to Smitterberg (2014) the mystery that surrounds these middle-seized owls is the fact that they live in close relationship with humans, and yet being able to keep a low profile. With its characteristic appearance and heart-shaped face, the Barn Owl is one of the most commonly known species of owls in the world (Barn Owl Trust, 2012). While the color scheme varies between the Barn Owls' different, geographically spread sub-species, the grey back, black eyes and facial shape remains the same. In Sweden, *Tyto alba guttata* has a sand colored chest, in contrast to the white-chested British Barn Owl (*Tyto alba alba*) (Mullarney *et al*. 1999; Smitterberg, 2014). Despite its fame, Barn Owls are not commonly spotted even in abundant areas (Stevenson & Fanshawe, 2002). However, their unmistakable shriek-like calling can be noticed much more frequently (Stevenson & Fanshawe, 2002).

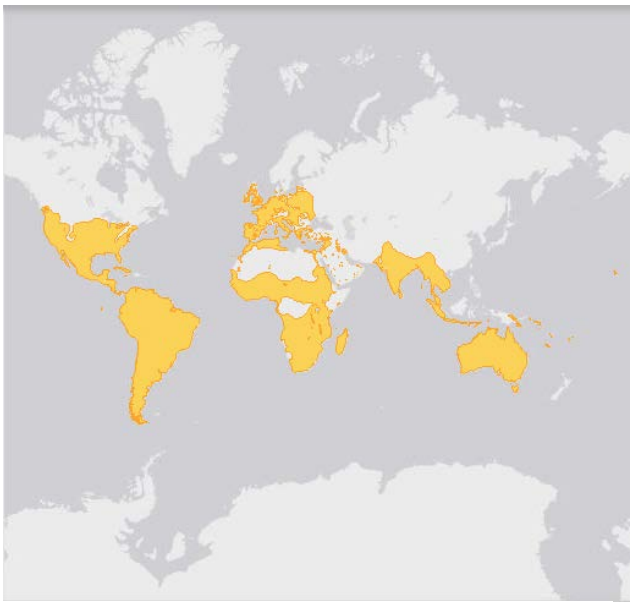

Fig. 1 Global distribution of Barn Owls (BirdLife International and NatureServe, 2014)

The Barn Owl is one of the most widely distributed owl species in the world with documented observations on most major continents (BirdLife International and NatureServe, 2014) (Fig. 1). The home range of the Barn Owl typically covers a massive area of up to 5,000 hectares, although only a smaller portion of it is used during the breeding period (April/May to July/August in the Northern hemisphere) (Barn Owl Trust, 2012). The nesting site typically consists of any suitable hole or structure, generally in old trees or farm buildings and barns (Barn Owl Trust, 2012; Hindmarch *et al*. 2012) and is often reused by the same breeding pair over several seasons (Walk *et al*., 1999). For hunting, Barn Owls generally have a preference for open grassland, absent of large vegetation (Muñuz & Murúa, 1990; Salvati *et al*., 2002).

While hunting, the Barn Owl flies close to the ground, face down, in search of small mammals such as Field Vole (*Microtus agrestis*) and Wood Mouse (*Apodemus sylvaticus*) (Barn Owl Trust, 2012; Taylor, 2009). In this paper, the prey of Barn Owls is referred to as 'small mammals'. According to Payne (1971), Barn Owls are able to locate prey in complete darkness using sound localization alone with an error of less than 1° in the vertical and horizontal planes, thus giving them the sharpest reported sense of hearing among all known species of birds (Barn Owl Trust, 2012). This extraordinary hearing is possible due to several different factors in the Barn Owl's anatomy. One of these are the fact that the ear slots are placed asymmetrically with one stationed somewhat higher than the other, resulting in sound waves reaching the left and right ear in a slightly different way (Campenhausen, 2006; Knudsen, 1979). Furthermore, the facial disk of the Barn Owl is

constructed from feathers accurately designed for reflecting sound waves, directing them to the owl's ear slots (Campenhausen, 2006; Knudsen, 1979).

2.2 Global status

Despite the fact that the Barn Owl is ranked as a "Least Concerned" species in the IUCN Red List of Threatened Species (IUCN, 2014) the Barn Owl population has faced a regional and in some cases national decline (Barn Owl Trust, 2012; Mullarney *et al*. 1999; Milchev & Gruychev, 2014). According to the Barn Owl Trust (2012) the British population has suffered a drastic decline. Despite once being regarded as one of the most common owls in Britain, no more than 4,000 pair remained by the turn of the millennium (Toms *et al*. 2000 in Barn Owl Trust, 2012). According to Mullarney *et al*. (1999) a similar trend has been observed in Sweden with the Barn Owl being classified as a rare and only locally observed species to date. With the global decline in the Barn Owl population, it can therefore be expected that the Swedish population has been affected in a similar way. In England, the charity-based organization Barn Owl Trust has, since its inception in 1988, actively dedicated its work to conserve this particular owl species (Barn Owl Trust, 2015). However, no such organization has been officially established in Sweden although the Swedish population is very small and classified as critically endangered (Artdatabanken, 2015).

2.3 Conservation Biology

In this paper, the definition of conservation biology constructed by Hunter and Gibbs (2007) is applied. According to Hunter and Gibbs (2007) conservation biology is defined as an "applied science of maintaining the earth's biological diversity". This is a wide definition that includes everything from the impact of human activity on the environment and specific species to the philosophical and law based ethics surrounding for example national parks as well as the economics of the humans affected by conservation methods. The main focus in this paper, however, will be the impact of human activity on wildlife common in the agricultural environment.

3. Aim and study question

The aim of this study was to examine and evaluate the state of the Swedish Barn Owl population as well as different conservation methods for Barn Owls and their applicability in Sweden. This study was made on behalf of the Barn Owl Trust in hope of supporting their reports on the status of the Barn Owl populations in Europe. This aim was approached through the following questions:

- What is the current status of the Swedish Barn Owl population?
- Why is the population in its current state?
- Which methods of conservation would be suitable for supporting the Swedish population, provided that it does need support and should be supported?

4. Methods

The chosen method for this survey was a literature study. To answer the questions in this paper, a collection of research material was gathered from the Web of Sciences scientific citation indexing service. A smaller collection in the form of scientifically based books and personal reports/messages from dedicated researchers, ornithologists and organizations was also assembled. Examples of organizations contacted during the course of this study where the Barn Owl Trust and the Scanian Ornithological Society (SkOF).

Examples of different search words used to find literature from the Web of Science are *barn owl conservation* (29 hits of which 5 relevant), *barn owl project* (16 hits of which 3 relevant), *barn owl farm* (5 hits of which 1 relevant) and *barn owl decline* (3 hits of which 3 relevant). Access was not granted to all the hits in the search and some were therefore excluded from the study.

The research reports excluded from this study where mainly papers focusing on veterinary medicine and therefore classified as not relevant for this review. However, articles on veterinary medicine with discussion on diseases affecting the Barn Owl population or related species were still classified as relevant and were therefore included.

5. Results

5.1 The Swedish Population

The first documented observation of a Barn Owl in Sweden was made in 1834 (Smitterberg, 2014). According to Smitterberg (2014) the owl was spotted on a ship in Ystad in the province of Scania in southern Sweden. Since then, the most well-known and well documented Barn Owl reproductions have been concentrated to this region (Smitterberg, 2014). However, as discussed by Jönsson (2000) and presented in the results of this survey, the Barn Owl has not been an annually documented resident in Scania. According to the results gathered in this study, the last documented breeding Barn Owl pair was observed in 2003 (Appendix 1). Ever since, only single individuals of Barn Owls have been observed in Scania (K. Bengtsson, SkOF, personal communication, 16 April 2015). Smitterberg (2014) however, mentions in his paper that the Barn Owl population through history has been very difficult to inventory, as a result of its discrete habits. This indicates the possibility that some individuals of Barn Owls may have avoided detection and thus remains outside the official records. According to the results in this study, several years between 1969 to present lack official observations of Barn Owls in Scania (Appendix 1). It is, however, unknown whether these gaps in the records are caused by a true absence of owls in Scania or only by the fact that no Barn Owls have been observed during these specific periods.

On the island of Gotland, recent records have shown indications of a population more stable than on the mainland (Smitterberg, 2014). According to P. Smitterberg (personal communication, 13 January 2015) the estimated population of Barn Owls on Gotland currently consists of 5-10 pairs with numbers shifting each year. According to Jönsson (2000) Barn Owls have been actively spotted on Gotland since 1990. One particular finding from 1992, a Barn Owl originally ringed in Hannover in 1989 (Tyrberg, 1993 in Jönsson, 2000) and recovered on Gotland, supports the theory of Smitterberg (2014) that Barn Owls in certain cases can migrate over open sea.

5.2 Possible reasons of decline

5.2.1 Intensive farming

Among all the reasons for decline in the Barn Owl population, the changes in farming methods are by far the most discussed in the literature gathered in this survey. As of date, agriculture has seen a rapid intensification and specializations (Colvin, 1985). As discussed by Colvin (1985) the main reason behind this change is the use of modern farming machines, pesticides and fertilizers. However, the more intensive farming systems have proven to have a negative effect on wildlife (Colvin, 1985; Chamberlain *et al.*, 2000; Hindmarch *et al*., 2012). In fact, negative effects to the British population of farmland birds have been observed since 1977 (Chamberlain *et al*., 2000). According to Lindström *et al*. (2012), a similar trend has been observed in Sweden during the last 30-40 years. This supports the theory that the limited population of Barn Owls in Sweden is the result of a national decline. In Barn Owls these effects are often related to reduction of suitable feeding areas (Colvin, 1985; Hindmarch *et al*., 2012) and destruction of nesting sites in the form of old farm buildings and trees (Hindmarch *et al*., 2012). According to Arlettaz *et al*. (2010) voles (*Microtus sp.*), which is by many classified as the main prey for Barn Owls (Frey *et al*., 2011; Bond *et al*., 2004), is most abundant in natural grasslands with many sight barriers. Today, these types of habitats are severely limited in modern farmlands with a weak small-mammal population and limited prey availability for Barn Owls as a result (Colvin, 1985). In addition, modern farming methods have proven to negatively affect the natural balance of nutrients in the farmland habitat resulting in nutrition-based disorders in Barn Owls (van den Burg, 2009).

Modern farming has also resulted in the destruction of wood- and grasslands neighboring the farms, in favor of the expansion of farmland. In fact, only 4% of the natural grasslands where still present in England and Wales by the end of the 1980s (Fuller, 1987). This, in combination with the destruction and replacement of old, open farmbuildnings with modern, closed buildings has resulted in a drastic decline in nesting sites (Hindmarch *et al*. 2012). According to Hindmarch *et al*. (2012) the great use of nestboxes by Barn Owls is a clear indicator of the absence of natural nesting sites.

According to Smitterberg (2014) secondary poisoning through pesticides is another negative factor caused by the more modern farming traditions. Several studies have shown the potency of modern pesticides and their effect on Barn Owl welfare (Hill & Mendenhall, 1980; Saravanan & Kanakasabai, 2004; Salim *et al*., 2014a; Salim *et al*., 2014b). In a survey by Salim *et al*. (2014b) some pesticides have a negative effect on Barn Owl breeding success, affecting both the parents and the owlets. Other pesticides studied by Salim *et al*. (2014a) were even reveled to be potentially lethal to adult Barn Owls.

5.2.2 Winter severity

The severity and duration of winters have shown to have a limiting effect on Barn Owl populations (Colvin, 1985; Chausson *et al*., 2014b). As shown in the literature, the impact of winters can be observed in several ways. As stated by Smitterberg (2014), the mortality of Barn Owls during severe winters is caused by the owls' inability to store fat thus making them more sensitive to feed shortage and starvation in comparison to for example Snowy Owls (*Bubo scandiacus*).

Furthermore, the severity of winters has been shown to be connected to the breeding success of Barn Owls (Chausson *et al*., 2014b). According to Chausson *et al*. (2014b) the number of breeding pairs was notably lower after a long winter. Chausson *et al*. (2014b) speculates that this could be a result of poor physical condition in the parents caused by a lack of sufficient nutritious feeding during the winter. In contrast, in a paper by Chausson *et al*. (2014a) no connection between clutch size and seasonal temperature during breeding was observed.

5.2.3 Effects of roads

Traffic on major roads is often classified as one of the major causes for mortality in Barn Owls (Barn Owl Trust, 2012). In a survey by Newton *et al.* (1997) 1 101 Barn Owl carcasses where examined with over 50% stated as having been killed by traffic. According to the results of Grilo *et al*. (2014), Barn Owls are most commonly killed by traffic while hunting and during the winter when food is scarce. This is caused by small patches of wild grass marking the boundary between roads and the farmland fields (Grilo *et al*., 2014). These small patches are commonly used for hunting by Barn Owls, as a result of a higher abundance of small mammals compared to the modern farmland fields (Bond *et al*., 2004).

However, several papers have criticized the methods for measuring the rate of road caused mortality in relation to the overall population claiming that the results doesn't reflect the reality in a sufficient way (Newton *et al*., 1997; Borda-de-Água *et al*., 2014), as the likelihood of finding and recovering carcasses is probably considerably higher along the roads as compared to other areas.

5.3 Conservation methods

5.3.1 Provision of nestboxes

Nestboxes (Fig. 2) are one of the most common methods for conservation of Barn Owls (Barn Owl Trust, 2012). Following the literature gathered in this survey nestboxing has been successfully applied all over the world from Canada (Hindmarch *et al*., 2012) to Israel (Meyrom *et al*., 2009). In a survey by Meyrom *et al*. (2009) in Israel 86,7% of the nestboxes became occupied while in Canada 80% of a group of surveyed nestboxes where occupied (Hindmarch *et al*., 2012).

The method of providing nestboxes has also been successfully applied in many other countries like the USA (Highfill & Boyd, 2002), Scotland (Shaw, 1994) and Switzerland (Frey *et al*., 2011). Thus the practice of nestboxing has a potential from a global perspective. According to Charter *et al*. (2010) the location of the nestboxes in relation to the sun has an effect on box usage by Barn Owls. In this case, since the study was performed in Israel, a country with hot climate, the Barn Owls preferred nestboxes aimed to the east and north

Fig. 2. Nestbox designed for Barn Owls erected in a modern farmbuilding.

and that where located in as much shade as possible (Charter *et al*., 2010). Charter *et al*. (2010) concluded that the Barn Owls chose the boxes offering the coolest day temperature but that these results may potentially differ depending on the climate of the area studied.

However, in some cases, nestboxes have been proven to have little or no effect on Barn Owl reproduction (Radley & Bednarz, 2005). According to Shaw (1994) the success of the nestboxing strategy is mainly dependent on the access of prey. This theory is further supported by the study of Radley and Bednarz (2005), in which nestboxes showed little effect on the Barn Owl population leading to the conclusion that lack of nesting spots was not the main limiting factor in that case.

5.3.2 Habitat protection

Research has shown a clear correlation between the population size as well as the breeding success of Barn Owls and the availability of small mammals, like voles (Shaw, 1994). Hence, the management of grasslands for Barn Owls should be aimed at maintaining a suitable habitat for small mammals (Barn Owls Trust, 2012). According to the Barn Owl Trust (2012), it is essential that the litter-layer is never completely destroyed if the aim is to maintain diversity and suitable hunting grounds for Barn Owls. The same author states that an unmanaged habitat is however not the solution, as it would result in overgrowth and ultimately turning grassland into woodland.

For this reason, some grazing or topping is essential in maintaining proper Barn Owl habitats (Barn Owl Trust, 2012). As stated by the Barn Owl Trust (2012) an optimal habitat of rough grassland is easily maintained through low-density cattle grazing. If cattle (or other grazing species) are not available the grassland can be topped at a height of 13 cm in a three-year rotation (cutting a third of the area each year) resulting in an aim for average year-round sward height of 20-30 cm (Barn Owl Trust, 2012). Research has shown that this particular sward height better supports the small mammal population compared to other cutting types (Askew *et al*., 2007).

However, as described by Arlettaz *et al*. (2010), simply maintaining an optimal habitat for small mammals may not result in suitable hunting grounds for Barn Owls. In the study of Arlettaz *et al*. (2012) natural areas of wildflower resulted in a great abundance in the small mammal population but low hunting success in Barn Owls as a result of the owls' inability to locate prey in the terrain studied in that particular case.

5.3.3 Captive breeding and release

During the course of this survey, no reports or records of any projects involving captive breeding and release has been uncovered. However, the theory behind this method can be questioned since Barn Owls have a proven sensitivity to captivity with abnormal hunting behavior as a result (Agostini, 1994), making it difficult to successfully establish captivity-bred birds in the wild.

5.3.4 Projects in Sweden

Today, only a handful of more or less private Barn Owl projects are active in Sweden (K. Bengtsson, SkOF, personal communication, 16 April 2015). According to K. Bengtsson from SkOF (personal communication, 16 April 2015) all of the projects active today are limited to nestboxing and none have been successful so far. This report is supported by L. Håkansson (personal communication, 11 January 2015) who has actively been erecting

nestboxes in southern Scania for 15 years to date. So far, no breeding has been reported in any of the nestboxes (L. Håkansson, personal communication, 11 January 2015). In 1996 the World Wildlife Fund engaged in a Barn Owl conservation project in Scania, however, this project was terminated in 2004 (P. Jönsson, personal communication, 16 April 2015).

According to P. Smitterberg (personal communication, 13 January 2015) the Ornithological Society of Gotland (GOF) launched a small nestboxing project in the late 1990s. However, this project has so far not given any results (P. Smitterberg, personal communication, 13 January 2015).

6. Discussion

To tie in with the purpose of this study, the reasons for historical Barn Owl decline on a global basis are numerous, as revealed by the research papers gathered in this survey. Thus, the decline of the Swedish Barn Owl population could be caused by more than one factor. As mentioned by Chamberlain *et al*. (2000), it can be difficult to pinpoint one single reason for the population decline. As further discussed by Martínez and Zuberogoitia (2004), Barn Owls can be particularly sensitive to change and other minor factors in the habitat. Thus one or several factors that may fall as inferior from a human perspective can play a major role to the owls. And as a result, pointing out one single factor as the general cause for the decline in the Swedish Barn Owl population may be difficult or even impossible.

According to Smitterberg (2014) the main reason for the limited and declining population in Sweden is the cold winters. This is plausible, both due to the high mortality discussed by Smitterberg (2014) as well as the effects of climate on breeding success studied by Chausson *et al*. (2014b). From another perspective it would also be a possible explanation to why the population has historically been more stable on Gotland than in the rest of Sweden, as the island generally has milder winters compared to the mainland.

However, with the proven effects of modern farming in the Barn Owl population in other countries (Colvin, 1985; Chamberlain *et al*., 2000; Hindmarch *et al*., 2012), the possibilities of negatives impacts of alternated farming methods on the Swedish population must still be considered, at least as a contributing factor. According to the survey by Smitterberg (2014) the Swedish Barn Owl population has potentially suffered from all the major effects of farming compiled in this paper: reduction in prey availability caused by habitat changes (Colvin, 1985; Hindmarch *et al*., 2012), destruction of potential nestsites (Hindmarch *et al*. 2012) and poisoning by pesticides (Hill & Mendenhall, 1980; Saravanan & Kanakasabai, 2004; Salim *et al*., 2014a; Salim *et al*., 2014b). However, it must be noted that some pesticides tested in the collected literature are outdated or, in some cases, banned in some countries today. The threat of these pesticides on the population today can thus be questionable. According to Lindström *et al*. (2012) Swedish farmland-related bird species have suffered a notable decline during the last 30-40 years. These reports are further supported in the survey by Chamberlain *et al*. (2000), who noted a significant change in the population of farmland birds following the changes in agricultural trends during the 1970s.

Then again, it may be difficult to evaluate the true status of the Swedish population with the information from the limited supply of literature collected in this survey. Mainly because very few articles focused on the Swedish population has been uncovered during this study. For example, the main report on the Barn Owl population on Gotland is the

survey by Smitterberg (2014). However, not much more the personal reports support Smitterberg's findings and thus it might be difficult to draw any conclusions on the status of the population. Therefore, a literature based survey, may not be the most suitable method for studies of this field.

As for the question about which conservation method(s) would be the most suitable for the Swedish population, it might be a question even more difficult to answer.

From what can be observed in the results of this paper, nestboxing has been one of the major global methods for conservation in Barn Owls (Barn Owl Trust, 2012). However, the results also point to a variation in the rate of success with some projects ending with a massive nestbox usage (Meyrom *et al*., 2009) while other projects have given very poor results (Radley & Bednarz, 2005). Radley and Bednarz (2005) hypothesize, quite logically, that the nestbox strategy is only viable when there is a lack of natural nesting sites in the habitat. This leads up to a conclusion that a conservation method carries no guarantees of success in making a difference for a population, especially if that specific method is not the most viable to begin with. Tying back to the teachings of Hunter and Gibbs (2007) the strategy of providing a resource, like nestboxes, in an environment is established around a simple basis. If the environment lacks a specific resource that thus acts as a limiting factor for a population, providing this missing "key" may be a both sufficient and efficient supporting strategy for the population (Hunter & Gibbs, 2007). Again, if the resource provided is not equivalent to the one missing, the strategy could be predicted to result in little or no effect for the population in question. However, as shown by Meyrom *et al*. (2009), provision of nestboxes may, during the proper conditions, act as a viable and effective method of conservation in areas with limited, natural nesting sites.

As a result of this reasoning, it can be suggested that the nestboxing strategy would most likely not be the most effective method of conservation in the Swedish Barn Owl population. Considering the results of nestboxing in Sweden in the past (K. Bengtsson, SkOF, personal communication, 16 April 2015), the ineffectiveness of the method may be high. According to Radley and Bednarz (2005) providing nestboxes can be used for evaluating the presence of other nesting sites in an area with a high usage of nestboxes indicating a lack of other, natural nesting sites. Thus, the low usage of nestboxes in Scania could theoretically indicate a high availability of natural nesting sites. However, according to K. Bengtsson from SkOF (personal communication, 16 April 2015), SkOF does not currently participate in any nestboxing projects due to the fact that there are no Barn Owls in the area to use the nestboxes. This report is supported by the findings on the Barn Owl population in Scania presented in this paper (Appendix 1). These findings suggest that the limited effect of nestboxes in Scania is caused by a complete absence of stationary or breeding Barn Owls in the area. Indeed, providing nextboxes for Barn Owls in Scania would hence be completely pointless.

Furthermore, nestboxes for Barn Owls have proven to be an attractive resource also for other owl species like Tawny Owls (*Strix aluco*) (Shaw, 1994) as well as other birds such as Common Kestrels (*Falco tinnunculus*) and Western Jackdaws (*Corvus monedula*) (J.Å. Hillarp, Katastrofhjälp Fåglar & Vilt, personal communication, 17 December 2014). As a result, it is possible that providing Barn Owl nestboxes could act as a supporting resource for other bird species like Tawny Owls and thus increase the interspecific competition, which may potentially damage the Barn Owl population further. However, no similar interspecific competition has been detected in feeding resources (Glue, 1967; Marks &

Marti, 1984) despite great similarity in feeding habits between species such as Barn Owls, Tawny Owls and Long-Eared Owls (*Asio otus*) (Glue, 1967; Nilsson, 1981; Marks & Marti, 1984).

According to Shaw (1994) the population of small mammals has a large impact on the Barn Owl population and the success of the strategy of providing nestboxes. This is further supported by Meek *et al*. (2009) who states that a stable population of small mammals is one of the basic resources vital for a stable population of Barn Owls. Additionally, the population of small mammals has suffered a decline as a result of modern practices in agriculture. Therefore, habitat conservation would be a suitable method for enhancing the population of small mammals and consequently favor the population of Barn Owls with an increase in the availability of suitable prey. In addition, it is possible that such a method could to enhance the population of other owl species, such as the Long-Eared Owl and the Tawny Owl, as well as many non-avian species. As a result, habitat conservation could be a method useful in a wider spectrum then just Barn Owl conservation.

However, the foreseen effect on the Barn Owl population can still be debated. Despite an enhanced availability of prey, the severity of winters may still have a limiting effect on the Barn Owl population. The number of breeding pairs has proven to be generally lower after a long and cold winter compared to milder winters (Chausson *et al*., 2014b). This is believed to be caused by a scarcity of efficient, nutritious feeding during winters. As a result, the Barn Owl population may still suffer despite extensive habitat conservation. In this study, no papers describing any attempts at supportive feeding during winters, similar to those common in eagles, have been found. Studies covering the possible effects of supportive feeding stations are therefore necessary to evaluate if the method could be applied in Barn Owl conservation in the future.

Again, based on the reports of K. Bengtsson from SkOF (personal communication, 16 April 2015), any method of habitat conservation and enhancement would have no effect since there would be no population of Barn Owls in Scania to support. The previous Barn Owl population in Scania was most likely based on a ‘spill-over’ from the Danish population, which has also suffered a decline during the last 10 years, and hence new spill-over events may not occur readily. So, what individuals should a new, expanding population stem from?

In Sweden, several projects of *ex situ* (outside of natural habitat) breeding and release into the wild have been conducted in owls, raptors and other avian species (Nordens Ark, 2015). As previously mentioned, no reports on similar projects on Barn Owls have been uncovered during the course of this study. According to the results of Agostini (1994) Barn Owls are more sensitive to negative changes in hunting behavior than other owl species, and may therefore be difficult to raise in captivity for reintroduction into the wild. However, the owls studied in this particular survey were held in an artificial- laboratory environment during the study. Hence, these results may not properly reflect what would happen in the wild with an owl breed in *ex situ* -but under ‘natural’ conditions. As a result, more detailed studies on the effects on behavior of captive breeding and release are necessary to evaluate the potential efficiency of such a method.

However, the method of captive breeding may also be evaluated from an ethical point of view. Today many wild animals suffer as a result of poor rehabilitation and careless releases into the wild (J.Å. Hillarp, Katastrofhjälp Fåglar & Vilt, personal communication,

14 December 2014). According to J.Å. Hillarp from Katastrofhjälp Fåglar & Vilt (personal communication, 14 December 2014), many rehabilitated and/or captive breed animals are later put down due to irreversible damage from careless handling and poor nutrition. The same source also report how some animals die shortly after release as a result of improper and/or unbalanced feeding. Thus, it is questionable if captive breeding can be qualified as a viable method with the risk of endangering the welfare and lives of the animals in the process. For this reason, release of captive-bred Barn Owls without a license is a legal offence in England with a possible fine not exceeding £5,000 and/or a six-month prison sentence per released bird (Barn Owl Trust, 2012). Furthermore, if the environment in Sweden is for some reason unsuitable for Barn Owls, it is possible that the Barn Owls released are doomed to suffer and die because they can not survive in the area of release. The question thus follows if captive breeding can be classified as an ethically viable method.

In addition, it is currently unknown hos an increase in the Swedish Barn Owl population would affect the ecosystem. As an effect of todays' small Barn Owl population, it is possible that an increase the number of owls could result in a trophic cascade. This, in turn, could result in further impacts on the ecosystem that may, or may not, be positive. On the contrary, since other owl species like Long-Eared Owls and Tawny Owls have similar feeding habits compared to Barn Owls (Glue, 1967; Nilsson, 1981; Marks & Marti, 1984) it is questionable if an absence of Barn Owls in Sweden would have any effects on the ecosystem.

Indeed, the true question may thus be whether any projects for conservation of Barn Owls should be applied at all in Sweden. If the cold winter climate is the main limiting factor for the Swedish Barn Owl population it is considerable that Sweden is not a suitable habitat for Barn Owls. Furthermore, it is therefore possible that the limited Barn Owl population in Sweden is not the result of a national decline but instead indicate that the Barn Owl as a species has never been fully adapted to the Swedish climate in the first place. As a result, none of the projects and methods for conservation presented in this paper may be viable in this case. It should, however, be taken into consideration that the projects in Sweden have so far been limited to nestboxing, according to the results gathered in this paper. Thus, the other methods discussed in this study (supportive feeding, providing and protecting natural habitat and captive breeding) may be attempted to investigate if they, in combination with providing nestboxes, may be used to support the limited population in the future.

7. Conclusions

To summarize, there are several different factors that may be responsible for limiting the population size of Barn Owls in Sweden with the long and cold winters identified as one of the main reasons. To date, the population is classified as critically endangered in Sweden with a small population on the island of Gotland but with no records of observation in Scania since 2010.

Despite global documentation of several methods of conservation, only the method of providing nestboxes has so far been applied in Sweden. However, with the owls sensitivity to cold climate it is possible that none of the methods of conservation speculated in this paper may result in a more stable population. Thus a passive approach with regular inventory of the population's national status may be the most suitable solution as of date.

This approach will be focusing on evaluating when the conditions may be more favorable and thus increasing the chances of desirable results from the projects.

8. Populärvetenskaplig sammanfattning

Tornugglan (*Tyto alba*), är en av de mest studerade och mest kända arterna av ugglor i världen. Tornugglan är dessutom en av de mest utbredda uggleärterna i världen med en utbredning över en majoritet av världens kontinenter. Trots sin spridning och att tornugglan som art inte idag är hotad har populationen genomgått en märkbar nedgång under de senaste decennierna. I synnerhet i England har denna reducering varit mycket tydlig. Trots att tornugglan en gång var klassad som Englands vanligaste uggla beräknades antalet ha sjunkit till ett ringa 4000 häckande par vid tiden för millennieskiftet.

I Sverige är tornugglan idag klassad som sällsynt och endast lokalt förekommande, vilket kan antyda att även den svenska populationen påverkats av den globala minskningen. Den enda, kända populationen av tornugglor finns idag på Gotland. Ett par exemplar har även påträffats i Skåne men den huvudsakliga populationen i landskapet tros vara utdöd. Studier har visat att den globala minskningen kan spåras tillbaka till 70-talet i samband med stora förändringar inom jordbruket. Till följd av att tornugglor historiskt sett bygger sina bon i gamla ladugårdar, något som givit upphov till dess engelska namn, ”*Barn Owl*”, har tornugglorna idag lidit en tilltagande brist på sina lämpliga häckningsplatser i och med att gamla, öppna ladugårdar rivs för att ersättas av moderna, stängda stallar i plåt. Utöver detta har det allt intensivare jordbruket med moderna maskiner och bekämpningsmedel resulterat i en minskning av tornugglans byten i form av små gnagare så som åkersork (*Microtus agrestis*). I Sverige har en liknande trend observerats för en rad olika fågelarter som lever naturligt i områden formade av jordbruk. Även dessa nedgångar har spårats till förändringarna i jordbruket på 70-talet vilket styrker teorin om att den svenska tornugglan kan ha påverkats på detta sätt.

Utöver detta är tornugglor dessutom känsliga för kalla och långa vintrar. Detta till följd av att tornugglor till stor del saknar förmågan att lagra värmande kroppsfett, vilket andra nordiska ugglor däremot kan göra. Förutom detta har det visats att antalet lyckade häckningar är märkbart lägre efter en kall och lång vinter i jämförelse med en mild och kort. Detta anses vara en följd av att tornugglorna inte är anpassade för att kunna jaga effektivt i djup snö och därför hamnar i dålig kondition inför häckningen efter en svår vinter.

I ett försök att motverka detta och stärka populationen har ett flertal projekt med uppsättning av holkar genomförts främst i Skåne och på Gotland. Emellertid har inget av försöken, trots år av observationer, givit några märkbara resultat. Många forskare tror att tillgången på föda är en av de mest avgörande faktorerna för en lyckad häckning hos tornugglor. Till följd av detta är det tänkbart att projekt riktade mot att utöka och skydda tornugglans naturliga jaktmarker vore en effektiv metod för att stärka tillgången på byten och därmed också tornugglorna. Denna metod skulle kunna kombineras med stödjande utfodring vintertid för att öka tillgången på föda under kalla vintrar för ugglorna.

Utöver detta har uppfödningsförsök med frisläppning på bland annat pilgrimsfalk och berguv visat sig effektiva. Frågan är om samma metod skulle vara möjlig på tornugglor. I den litteratur som undersökts i denna studie har inga rapporter kring sådana projekt kunnat hittas.

Emellertid kan det ifrågasättas huruvida någon av dessa metoder skulle visa sig effektfull eller ens nödvändig i Sverige. Om tornugglan inte är fysiologiskt anpassad för att klara det

kalla klimatet i Sverige vore kanske en passiv inställning vara en mer skonsam lösning. Detta istället för att lägga ekonomiskt stöd till en art som i vilket fall kommer att lida till följd av Sveriges kalla vintrar, och där dödligheten således kan förväntas vara hög. Det kan därför finnas skäl att diskutera om befintliga tidsmässiga och ekonomiska resurser kan göra större nytta om de fokuseras på andra arter i behov av bevarandeåtgärder.

Sammanfattningsvis kan ett projekt begränsat till endast inventering av antalet individer i landet vara en mer stabil lösning på kort sikt. Eventuellt, med fler mildra vintrar och en vidare invandring av tornugglor från andra länder kan antalet ugglor en dag nå en nivå då det kan vara mer effektivt att vidta ytterligare åtgärder.

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10. Appendix

Appendix 1. Summary of observations of Barn Owls in Scania from 1969-2010, reported by the Scanian Ornithological Society. White – no documented observation, grey – observed.

Year	Documented, alive	Documented, dead	Documented pair	Documented nesting	Documented hatching
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2008					
2009					
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