

LARUS Hrvatska akademija znanosti i umjetnosti	57 (2022)	13-27 str. 5 slika	Zagreb 2022.
	Primljeno 16.7.2022. Prihvaćeno na sjednici Razreda za prirodne znanosti HAZU 17.11.2022.		

UDK 598.279.42(497.5)

Original scientific paper
Izvorni znanstveni članak
DOI: 10.21857/m16wjcnxx9

A FIVE-YEAR (2018 – 2022) STUDY OF THE EAGLE OWL *Bubo bubo* IN CROATIA

The recolonisation and number estimates of the Eagle Owl in lowland Croatia

*Petogodišnje istraživanje (2018 – 2022) ušare Bubo bubo u Hrvatskoj
Rekolonizacija i procjena brojnosti ušare u nizinskoj Hrvatskoj*

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ABSTRACT

The Eagle Owl *Bubo bubo* is one of the largest owl species in Europe and Asia. It mainly inhabits rocky areas with suitable cliffs, where it nests. The global population trend is declining. In Croatia, the largest part of the population breeds in the Mediterranean part. The population in the lowland part was extinct in the first half of the 20th century, but recently they have been observed breeding again. The aim of this paper was to present the results of a five-year study of the Eagle Owl in three parts of Croatia: the lowland, the Primorje and Gorski kotar; and Istria. From 2018 to 2022, educated volunteers collected data about the Eagle Owl active territories by listening to spontaneous singing from 1st February until 15th March. A total of 485 visits were made to 154 locations, and 60 active territories of the Eagle Owl were found. The estimated size of the breeding populations in the lowland part is 32 to 45 active territories, while for Primorje and Gorski kotar, as well as Istria, further research ought to be conducted in order to estimate the population size.

Keywords: Eagle Owl, *Bubo bubo*, passive survey, volunteers, quarry, census

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INTRODUCTION

The Eagle Owl *Bubo bubo* is one of the largest owls (Strigidae) distributed throughout Europe and Asia. It inhabits mainly rocky areas with cliffs and ravines, caves, patches of woodland, and generally undisturbed wilderness. It uses open forest, taiga, and wooded steppe, river valleys with gorges, overgrown quarries and farmland with suitable rocky areas or cliffs. The Eagle Owl is listed as least concern (LC) species, but the global population trend is in a decline (MIKKOLA 1994, BIRDLIFE INTERNATIONAL 2022).

In most European countries, the Eagle Owl population declined sharply from mid-19th and into the 20th century. The Eagle Owl was extinct in Belgium, Luxemburg, and Denmark, while its population in most of Germany, Austria, France, Sweden, and Estonia declined heavily (LUDWIGSDORF *et al.* 1982, OLSSON 1997, BWPI 2006, MARTIN *et al.* 2017). There are several reasons for this, as poaching, egg collecting and stealing of the nestlings, as well as increase in traffic and the number of power lines, resulting in increased occurrences of electrocution and collision events (LUDWIGSDORF *et al.* 1982, MIKKOLA 1994, RADLER & BERGERHAUSEN 1998). Another issue was poisoning due to unregulated pesticide use, mostly mercury and DDT (OLSSON 1997, SCHAUB *et al.* 2010). In order to help recover the population, the Eagle Owl was reintroduced in Germany, leading the population to expand to Belgium, eastern France and Luxemburg (LUDWIGSDORF *et al.* 1982, RADLER & BERGERHAUSEN 1988, DALBECK & HEG 2006) According to the BirdLife International (2015, 2022), the European population is increasing today.

In Croatia, the majority of the Eagle Owl population breeds in the Mediterranean part, from Istria to southern Dalmatia. It is also found in the mountainous area, while in the lowland, it went extinct in the first half of the 20th century (KRALJ 1997, TUTIŠ 2013, BARIŠIĆ *et al.* 2016). Today, the population estimate is 800-1200 breeding pairs (TUTIŠ 2013). Recently, an Eagle Owl has been found breeding in lowland Croatia again (ASSOCIATION BIOM, unpublished data). This discovery led to the establishment of the first Eagle Owl breeding census in lowland Croatia, similar to the census programme in Slovenia, with the aim of collecting data about the return of the Eagle Owl to this area (RUBINIĆ 2004, DOPPS & BIOM 2022). Parallel to that, the same census started in Istria through the Interreg Slovenia-Croatia project LIKE – Living on the Karst Edge, to estimate the size of the Eagle Owl population in the region. In order to cover this large geographical area, many knowledgeable volunteers participated in the monitoring by listening for spontaneous calls of the Eagle Owl, thus checking their presence in a suitable habitat. Like in many bird species, the male Eagle Owl defends its territory by singing throughout the year, but the vocalization is most frequent in the period before egg-laying, while the females are less vocal and sing mostly to communicate with the male (DELGADO & PENTERIANI 2006). In some studies,

researchers also use playback to detect Eagle Owl territory (DELGADO & PENTERIANI 2006, BARIŠIĆ *et al.* 2016). This species is not easy to observe because it is nocturnal, with cryptic plumage, and often lives on hard terrain, which makes these two methods appropriate to study the species.

In this study, we present data collected through the five-year census of the Eagle Owl breeding population in Croatia, especially in the lowland area, where it was once thought extinct.

MATERIALS AND METHODS

Study area

The study area was divided into three parts for easier coordination of volunteers: the lowland, Primorje and Gorski kotar, and Istria (Figure 1).

The lowland includes eastern, northern and central parts of Croatia. Quarries are the most common and suitable locations for the Eagle Owl nesting in this part with the combination of open areas, predominantly agricultural land. Aside from that, the central part has some patches of surface limestone and karst habitats mostly related to river canyons and surrounding cliffs. Primorje and Gorski kotar represent the part of the Primorje-Gorski kotar County. Gorski kotar is a mountainous area in northern part that has a lot of rocks, vertical walls and cliffs due to the presence of carbonate rocks and associated karst habitats. Open landscapes are present but forest predominates. Primorje, respectively the seacoast and the islands, has more karst habitats with an open land that is suitable for the Eagle Owl breeding. The Istria part represents the Istria County, which includes almost the entire Istrian peninsula. The terrain consists mostly of karst habitats, farmlands, grasslands, and forests.

All the examined locations were defined by the presence of quarries, and natural rocky habitats with tall, slightly overhanging carbonate rocks characterized by fissures, holes, and ledges that Eagle Owls use as breeding sites with the combination of open areas like farmland, grassland, and meadows, where they hunt. Breeding Eagle Owls had previously been found on some locations, however the most of the researched locations were identified through desktop study using satellite images. They were later confirmed as suitable during fieldwork, mostly by how large and high the rocky area is and if there are holes, ledges or depressions high enough where Eagle Owls might have a nest protected from terrestrial predators.

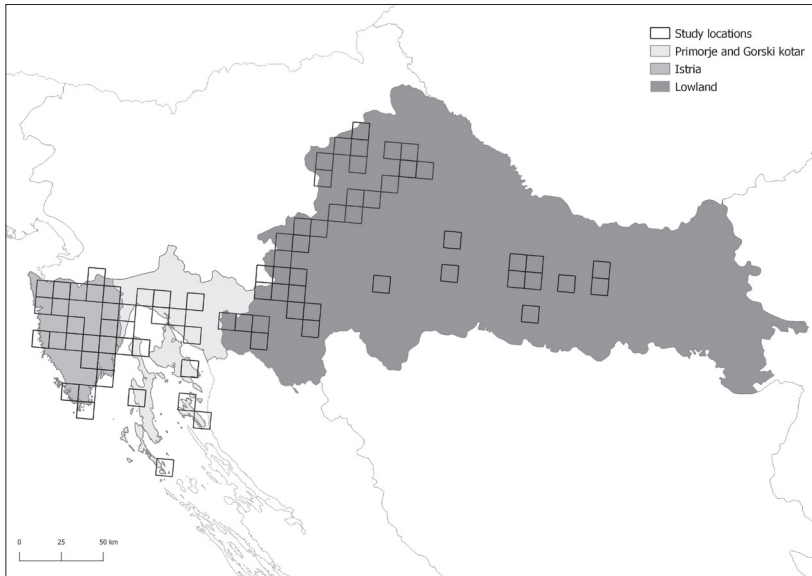


Figure 1. The study area of the Eagle Owl *Bubo bubo* in Croatia separated into three parts: the lowland, Primorje and Gorski kotar, Istria. The studied potential breeding locations that are shown as 10×10 km quadrants.

Slika 1. Područje istraživanja sove ušare *Bubo bubo* u Hrvatskoj, podijeljeno na tri dijela: nizinski dio, Primorje i Gorski kotar, Istra. Potencijalne lokacije gnijezdilišta su prikazane kao 10×10 km kvadranti.

Methodology

From 2018 to 2022, the census of Eagle Owls has been conducted on 154 different locations: 85 in lowland, 18 in Primorje and Gorski kotar and 51 in Istria (Fig. 1). 18.8% of locations were studied every year, 15.6% for four; 14.9% for three; 20.8% for two; and 29.9% only for one year.

The study was carried out during the second half of winter, mostly from 1st February to 15th March. In this period, Eagle Owls are highly vocal because males are defending their territories and communicating with the females before and during the egg-laying phase (PENTERIANI 2002, HARMS 2020). We used passive auditory survey to study active territories of the Eagle Owl that were defined as such if a singing male or a duet between a male and a female was heard. The survey was done with the help of volunteers, as they checked potential and known breeding locations in the field either as a group or individually. For safety reasons, since many locations are quite remote, volunteers were encouraged not to be alone in the field.

Volunteers were introduced to the methodology, biology and ecology of the species before conducting fieldwork. Each volunteer learnt how to recognise the singing of male and female Eagle Owls. The two can be easily separated by given calls, with the male having a deep, sonorous booming “uu-hu” sound and the female a higher pitched sound (BWP1 2006).

During calm evenings with no precipitation and little or no wind, volunteers positioned themselves at the location 30 minutes before sunset. Hidden and quiet, they waited until they either heard an Eagle Owl singing or complete darkness, roughly when 10 stars are visible in the sky (DOPPS & BIOM 2022). In total, the activity lasted around 1.5 hours. If volunteers heard singing, they had to record the sex, direction and approximate distance of the bird.

Additional information were collected during the fieldwork: start and end time, weather conditions (wind, precipitation, and cloudiness), noise, potential threats to the Eagle Owl, and other observed species. Each location was photographed. For wind and noise, volunteers had to choose between four conditions: calm (no wind / no noise), weak (little wind / noise but not affecting hearing), medium/moderate (affecting hearing), and strong/loud (impossible to listen).

The population size was estimated only for lowland Croatia, where the majority of suitable locations were checked. Locations visited during the study with no Eagle Owl found were taken into account for setting the upper level of the population estimates, only if the locations seemed suitable for Eagle Owl breeding. Since in some areas, territories are far away from each other, it is possible that in these parts, the Eagle Owl is not as vocally active as in areas with denser population (PENTERIANI 2003). Therefore, some active territories may have been missed during this study.

RESULTS

Active territories

In five years, 2018 – 2022, a total of 485 visits were made to 154 locations with 60 active territories found in the study area. Six visits were not included in the results, since they were made during strong wind, which was not in accordance with the study protocol.

From 85 visited locations in the lowland part, 32 had active territories (37.64%); from 18 locations in Primorje and Gorski kotar, 11 had active territories (61.11%); whilst from 51 locations in Istria, 17 active territories (33.33%) were found (Figure 2). The estimation of active territories was done only for the lowland part, with an estimated number ranging between 32 and 45 territories.

Singing was heard during 195 visits, and 157 times (80.51%) they came from the male that was quite often also seen. Both males and females sang together 34 times (17.44%), including one instance of two females singing together with one

male. A female singing alone was observed only 4 times (2.05%). The Eagle Owl was only seen without hearing it singing once in Istria, at a previously unknown breeding location. It was not included as an active territory, since it didn't show any territorial behaviour so we cannot exclude the possibility that this was an immature individual.

At the beginning of 2018, the number of volunteers participating, covered locations, and active territories found were the lowest. The number of checked locations and active territories found increased in 2019 and 2020, while in the last two years, 2021 and 2022, they remained similar. Only the number of volunteers involved continued to rise yearly (Figure 3).

Time and weather conditions

Most visits were done from 1st February until 15th March (94.31%). The earliest successful visit, when the Eagle Owl was heard, took place on 15th January, and the latest on 31st March. Following the methodology, visits were conducted when the conditions were suitable. Most visits (81.23%) had calm wind conditions or a light breeze and no precipitation, while the rest were made during light rain with six observed males singing (Figure 4a; 5a). According to the cloud cover, 69.69% of visits were made with cloud covering less than 50%. Singing was heard through all cloud cover stages (Figure 5b). About half of the visits (56.49%) were made without or with weak noise, 29.48% with moderate, and 2.68% with loud noise. The noise source was mostly traffic, springs and waterfalls, activity in the quarry, dogs, and nearby settlements (Figure 4b). Most locations were visited at the temperature range of 5-10° C (39.79%), then at 0-5° C (27.62%), >10° C (16.08%), <0° C (5.36%) and the rest had no data about temperature (11.13%).

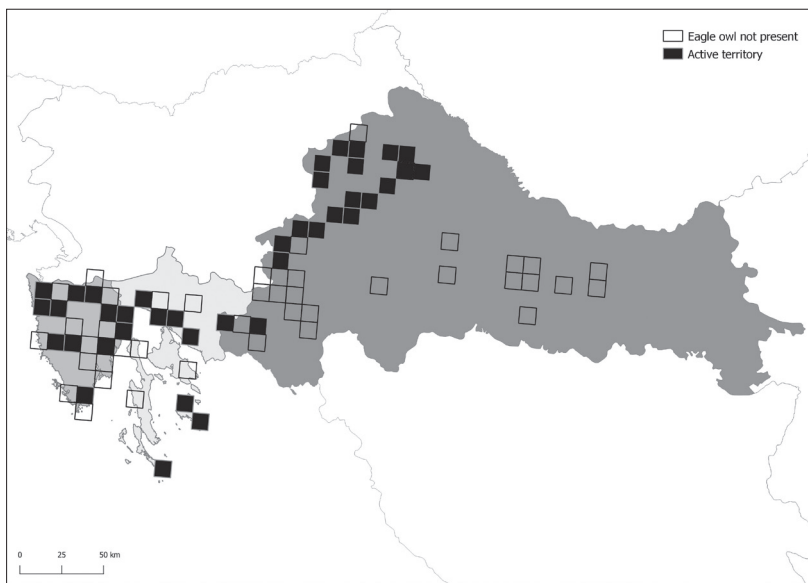


Figure 2. The locations of the Eagle Owl *Bubo bubo* study in Croatia, presented as 10x10 km quadrants. Black quadrants are locations with found active territories, while in the white quadrants the presence of the Eagle Owl was not confirmed.

Slika 2. Lokacije istraživanja sove ušare *Bubo bubo*, predstavljene kao 10x10 km kvadranti. Crni kvadranti označavaju lokacije na kojima su pronađeni aktivni teritoriji dok u bijelim kvadrantima aktivnost nije potvrđena.

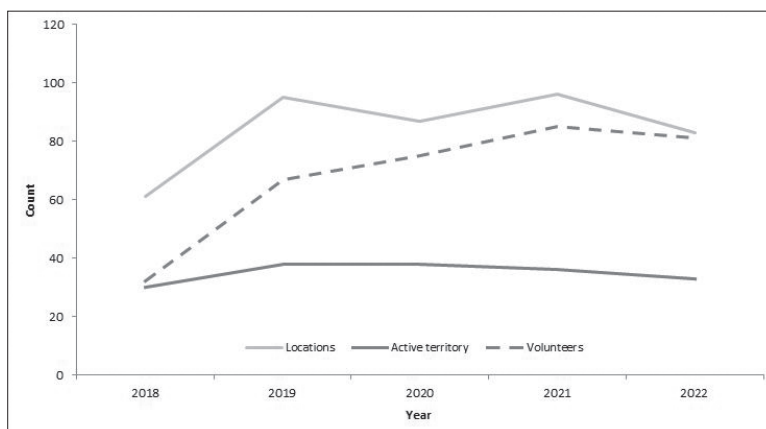


Figure 3. The number of covered locations, found active territories and volunteers that were participating in the study from 2018 to 2022.

Slika 3. Broj istraživanih lokacija, pronađenih aktivnih teritorija te broj volontera koji su sudjelovali u istraživanju od 2018 do 2022.

DISCUSSION

Our study shows that the Eagle Owl is breeding again in the lowland part of Croatia, where it was thought to be extinct. During late 19th and early 20th century, numerous individuals were collected for museums in north-western and eastern Croatia, which suggests that this species was once numerous in this part (GRBAC & KRALJ 2008). It is not clear when the population spread again to this part, but improved legal protection and decreased poaching played a big role in the repopulation. Furthermore, strong population in the Mediterranean part of Croatia and Slovenia probably helped in spreading to the lowland of both countries. In Slovenia, comparing the data available from the previous breeding atlas from 1995 with the new data from 2002 to 2017, shows that the Eagle Owl had been breeding mostly in Kras and Vipava valley. However, due to better research and natural spreading of the species, it was also found in Posavsko Hribovje near Celje which is naturally related to Žumberak and Samoborsko Gorje in lowland Croatia (MIHELIČ 2019).

The estimation of the population size based on this study is only possible for the lowland part, because most of the potential locations have been checked in this area for active Eagle Owl territories. It is estimated that the lowland holds 32-45 breeding pairs.

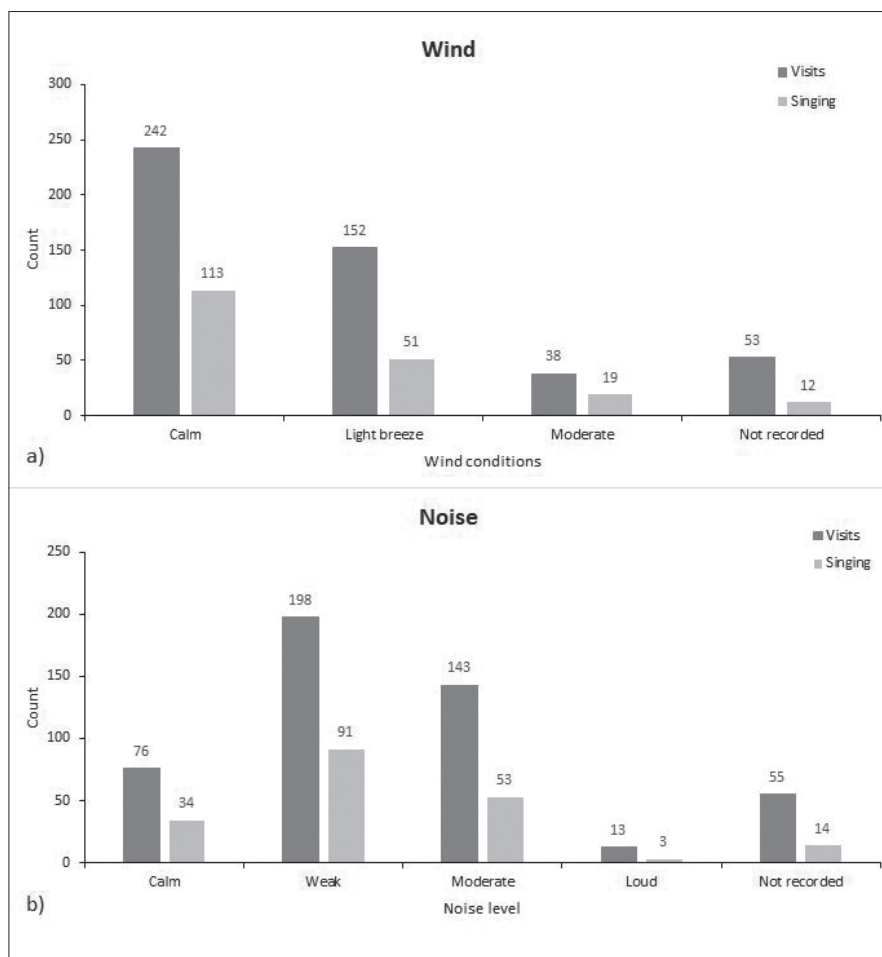


Figure 4. The number of visits and the observed Eagle Owl *Bubo bubo* singing during: a) wind conditions: calm, light breeze, moderate wind, data not recorded; b) noise level: calm, weak, moderate, loud, data not recorded.

Slika 4. Broj posjeta i glasanja sove ušare *Bubo bubo* tijekom: a) uvjeti vjetra: tiho, slab povjetarac, umjeren vjetar, jak vjetar, podaci nisu zabilježeni; b) razine buke: mirno, slaba, umjerena, glasna, podaci nisu snimljeni.

The number of active territories in Primorje and Gorski kotar is probably higher than it was found during this study. There are still many potential locations that should be checked before estimating the population size in this part. This area has a large number of cliffs, many of which are sea cliffs, thus hardly approachable. Additionally, detectability in coastal areas, compared to inland sites, is often reduced due to strong wind.

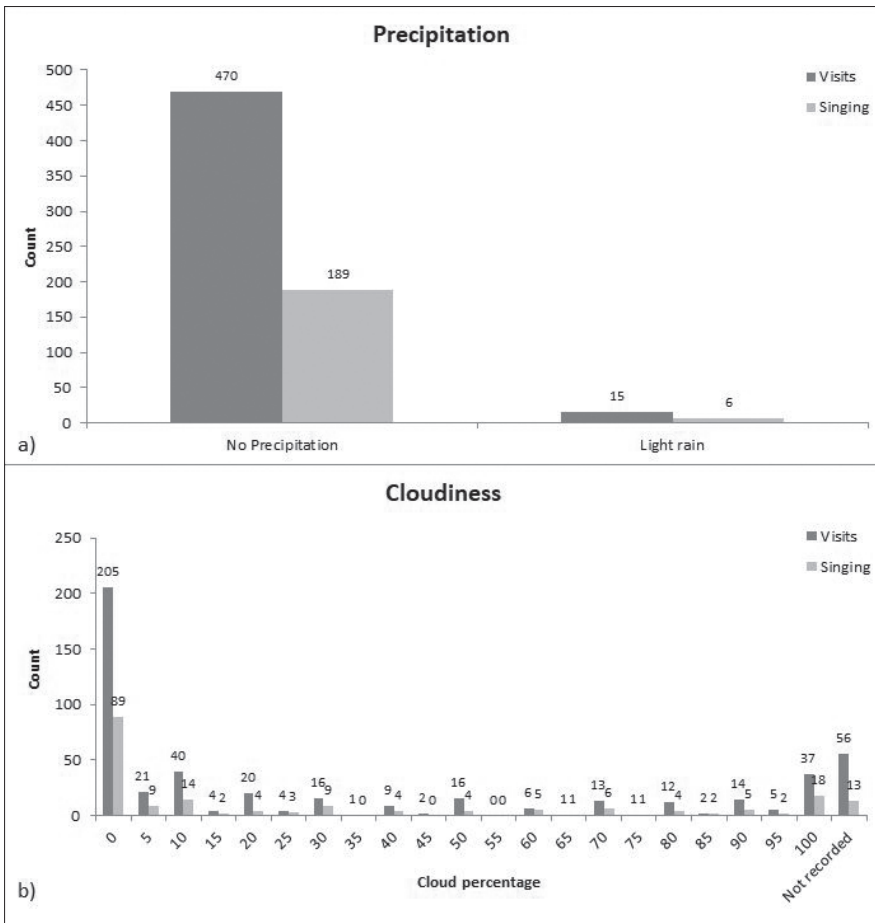


Figure 5. The number of visits and the observed Eagle Owl *Bubo bubo* singing during: a) precipitation: no precipitation, light rain; b) percentage of cloud cover, 0 (no clouds) – 100 (sky completely covered with clouds).

Slika 5. Broj posjeta i glasanja sove ušare *Bubo bubo* tijekom: a) oborina: bez oborina, slaba kiša; b) postotak naoblake, 0 (bez oblaka) – 100 (nebo potpuno prekriveno oblacima).

The distribution of registered active territories in Istria is similar to the historical records that were mostly found on the Učka Mountain and the Ćićarija karst plateau, the Lim Bay together with Limska draga, the valley of the river Mirna and one territory around Pula (RUCNER 1998, LUKAČ & STELKO 2016). It seems that the geographical distribution has not changed much, but there are unfortunately no records on the historical size of the population to compare. In this part, there are still many unchecked locations, mostly in the northern part of Ćićarija, which could hold more Eagle Owl territories. It is important to continue with the study in this area, especially on the Ćićarija karst plateau, before estimating the population size.

The area with the biggest gap in recorded active territories is in the lowland part, specifically south of Karlovac and the hills surrounding the Požega valley. Both parts seem to provide a good habitat with irregular topography that the Eagle Owl prefers (ORTEGO 2007). The area around Karlovac is quite forested, but it has quarries and river canyons surrounded by an open landscape too. Considering that the Eagle Owl was found breeding in more forested areas near Ogulin and even further south on the Velebit Mountain, it should be possible for it to inhabit that area (B. JEČMENICA, unpublished data). Interestingly, the same gap exists across the border in Slovenia (MIHELČ 2019). Hills surrounding the Požega valley have several active and inactive quarries surrounded by agricultural land that fits the Eagle Owl habitat in the western part of the lowland, but it has not been found there during this five-year study. Historically, there are observations of Eagle Owls breeding in this part by local ornithologists (N. Šetina pers. obs.), and one specimen from Kutjevo at the Croatian Natural History Museum in Zagreb (GRBAC & KRALJ 2008). There are currently no known reasons why the Eagle Owl should not return to this area; it is thus important to continue with the study in this part.

The Eagle Owl breeds in close vicinity to people mostly in the lowland part, because quarries are the best suitable places for nesting due to the lack of natural rocky areas and cliffs. The presence of quarries probably enabled the Eagle Owl to occupy this area, far from its natural rocky habitat. Similar findings appear in Italy and France, where the Eagle Owl is intensely using human-altered habitats (MARCHESI *et al.* 2002, MARTIN *et al.* 2017). The Eagle Owl was commonly found breeding in large, active quarries that have enough space for the Eagle Owl to find a location with no direct human disturbance, and it seems they get used to activities in the quarries. A study in Hungary shows that they tolerate both human and machine activity that occurs regularly, but only if they remain far enough, because irregular activities closer to them may endanger the breeding (PROMMER *et al.* 2018).

Even though the Eagle Owl is a bird of wilderness, it seems that it is capable of adapting well to human-altered habitats, however at the cost of frequent disturbances not only by the activity in quarries but also by hikers, motocross, shooting polygons, illegal rubbish dumps or entertainment like concerts and parties. These activities were regularly observed during this study near or occasionally inside the quarries.

In their natural habitat, rock climbing and the constant presence of people (intruders) close to the nest site represent an obstacle to which the Eagle Owl cannot adapt. On locations where rock climbing is frequent, the Eagle Owls have not been observed during this study. It is known that climbing can cause territory abandonment (OLSSON 1997, KOCE *et al.* 2020). Contrary to other types of visitors who are “just passing by”, rock climbers usually spend most of the day resting

close to the wall or actually climbing on the wall; thus their influence on the Eagle Owls is highly specific. There are multiple examples in the study area and close vicinity (the Kras region in southern Slovenia), where Eagle Owls are not present anymore due to rock climbing activities on cliffs with historical records of the Eagle Owl breeding (KOCE *et al.* 2020). There is also an example from Štrkljevica area in Slovenia (MIHELIČ *per. obs.*), where the Eagle Owl left the breeding area due to constant disturbance by rock climbers, only to return after the rock climbing was banned. During this study of Eagle Owls, we have recorded few exceptions, where rock climbing and Eagle Owls can coexist in close vicinity under specific conditions. The breeding cliff ought to be physically divided from the rock climbing area in order to ensure undisturbed breeding (an example from the Kalnik location, where the Eagle Owl is showing territorial behaviour on the opposite side of the climbing and hiking routes). Visitor management ought to be carefully organized with “free zones” and “no entry zones” (example from Istarske Toplice). With the growing popularity of various outdoor sports, this topic needs further research in order to protect not only the Eagle Owl, but also other natural values that can be influenced by specific visiting models.

During the five-year period, the number of volunteers increased each year, yet the number of locations covered and found active territories did not. One reason for this is that usually, more than one volunteer was checking one location at the same time; and second, due to the limited time volunteers can offer, it is usually not possible to check each location more than once in a season. If the weather conditions are not suitable or the Eagle Owl is not singing for an unknown reason at the time when volunteers are present, the active territory will not be confirmed. One of the solutions, besides increasing the number of volunteers, could be to start earlier, to give volunteers more time to participate, considering that singing of Eagle Owls was observed as already as in mid-January in all three parts of Croatia.

In all three study areas, mostly males (80.51%) were heard. A very similar result was provided by HARMS *et al.* (2020), where most territories were also found by listening to male singing (85%). This is not surprising, because the males are more vocal than the females (DELGADO & PENTERIANI 2006). It is not possible to conclude whether there are any connections between the Eagle Owl singing frequency and the weather conditions, since the data are biased in favour of weather without rain, clouds, and wind, as the methodology requires.

Being a top predator, the Eagle Owl is a good indicator of change in the environment. Since it was distributed in the lowland before, returning to this area is a good sign that the population is increasing, and it should be of great importance to continue the study not just in these three parts of Croatia, but also on central and southern Adriatic coast that holds most of the Croatian population (TUTIŠ 2013).

Acknowledgments

We would like to thank all the volunteers who participated in the study throughout these five years, and made this paper possible. Their good will, free time, local knowledge about potential locations, and overall commitment were crucial for the success. Furthermore, we would like to thank Tomaž Mihelič for all the help in the first years of the study. His vast knowledge about Eagle Owls and his generosity made our job much easier. We are very grateful to Jelena Kralj, who dedicated her time to guiding the writing of this paper and to Vanja Novosel for proofreading the text. Finally, we would like to thank the reviewers for their time and effort in revising this paper. We sincerely appreciate all your comments and suggestions which helped improve the paper.

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SAŽETAK

Ušara *Bubo bubo* je jedna od najvećih vrsta sova u Europi i Aziji. Uglavnom nastanjuje stjenovita područja te staništa s prikladnim liticama na kojima gnijezdi. Globalni tren populacije je u padu. Strmi pad europske populacije uslijedio je sredinom 19. i početkom 20. stoljeća, a razlozi smanjenja brojnosti su krivolov, izgradnja infrastrukture te trovanje. U Hrvatskoj se najveći dio populacije ušare gnijezdi u mediteranskom dijelu zemlje. Populacija u nizinskom dijelu Hrvatske bila je izumrla u prvoj polovici 20. stoljeća, no recentni podaci pokazali su da ušara ponovno naseljava i taj dio zemlje. Na temelju toga pokrenut je program praćenja stanja ušare u Hrvatskoj. Cilj ovog rada bio je prikazati rezultate petogodišnjeg istraživanja ušare u Hrvatskoj. Područje istraživanja je podijeljeno na tri dijela: nizinski dio, Primorje i Gorski kotar te Istru. Od 2018. do 2022. istraživanje se provodilo u razdoblju od 1. veljače do 15. ožujka kada je mužjak ušare vokalno najaktivniji. Educirani volonteri na terenu su metodom pasivnog osluškivanja prikupljali podatke o prisutnosti ušare te bilježili podatke o vremenskim prilikama, buci i prijetnjama. Odrađeno je ukupno 485 posjeta na 154 lokacije na kojima su pronađena 60 aktivna teritorija ušara. U 80,51% slučajeva zabilježeno je glasanje samo mužjaka. Istraživanje je većinom odrađeno u dobrim vremenskim uvjetima, što je preduvjet metodologije. Ovo istraživanje pokazalo je da se ušara ponovno gnijezdi u nizinskom dijelu Hrvatske gdje su važnu ulogu imali bolja zakonska zaštita i smanjen progon, a repopulacija je vjerojatno bila moguća zbog snažnih populacija u mediteranskom dijelu Hrvatske i Slovenije. U tom dijelu zemlje važan element staništa predstavljaju kamenolomi koji su svojevrsna zamjena za prirodne stijene. Procijenjena veličina populacija u nizinskom dijelu je 32 do 45 parova, dok za Primorje i Gorski kotar nije moguće procijeniti veličinu populacije zbog nedovoljno istraženog područja. Rezultati pokazuju izostanak ušare na dva područja u nizinskom dijelu s naizgled povoljnim staništem. Ovaj rad upućuje na povratak ušare u nizinskom dijelu zemlje te potrebu za sustavnim monitoringom te detaljnijim istraživanjem u Primorju i Gorskom kotaru te Istri.

