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SUBURBAN BIODIVERSITY: THE IMPORTANCE OF A SMALL SPA NEAR ZAGREB FOR RIVERINE BIRDS

Prigradska bioraznolikost: važnost malog POP-a kraj Zagreba za riječne ptice

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ABSTRACT

The Special Protection Area (SPA) Sava near Hrušćica with the Rakitje gravel pit (HR1000002) is one of the smallest SPAs in Croatia. A total of 171 bird species were recorded within the study area, of which 87 were breeding. Almost half of all recorded species (82 species, 48%) and 30% of breeders (26 species) are associated with wetland or riverine habitats. Target species for this SPA are Common Tern *Sterna hirundo*, Little Tern *Sternula albifrons*, Kingfisher *Alcedo atthis*, Common Sandpiper *Actitis hypoleucos*, and Sand Martin *Riparia riparia*. Estimated numbers of breeding pairs for all target species are higher than their respective conservation targets, except for the Little Tern which disappeared as a breeding species in this area. Four other bird species listed on Annex I of the EU Birds Directive should be considered for the addition as target species for this SPA. The main identified threats comprise periodic flooding of breeding islands caused by operations of hydropower plants (hydropeaking), gravel extraction, and vegetation encroachment of nesting sites. Due to the effective management of nesting habitats by two Natura 2000 management units (Zeleni prsten Public Institution of Zagreb County and Zagreb City Nature), the SPA Sava near Hruščica with Rakitje gravel pit remains the most important breeding area for the Common Tern in Croatia.

Keywords: SPA Sava near Hrušćica with the Rakitje gravel pit, avifauna, threats, conservation measures

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INTRODUCTION

The Natura 2000 network of the European Union is established to protect and restore biodiversity across Europe. It includes Special Areas of Conservation, which are designated to protect a range of habitats and species, and Special Protection Areas (SPAs) designated to protect bird species of conservation interest. The objective of the Natura 2000 network is to maintain listed habitats and species at a "favourable conservation status" (European Commission 1997). Achieving this goal requires effective management, implementation of conservation actions, and monitoring of both target habitats and species.

In Croatia, 38 SPAs have been designated, covering a total area of 18,147.7 km^2 (https://bioportal.hr/gis/). The SPA Sava near Hrušćica with the Rakitje gravel pit (HR1000002) is one of the smallest SPAs in the country, situated in suburban area of the Croatian capital, Zagreb. Despite its small size, it hosts the largest share of the national population of the Common Tern *Sterna hirundo* (Kralj *et al.* 2019). This SPA was designated to protect several bird species that inhabit riverine habitats: Common Tern, Little Tern *Sternula albifrons*, Common Sandpiper *Actitis hypoleucos*, Kingfisher *Alcedo atthis*, and Sand Martin *Riparia riparia*. Over the past decade, the Common Tern population was continuously monitored and studied, and at the same time, the monitoring of avifauna was undertaken at different parts of this SPA.

This study aims to present data on the population size, threats, and management opportunities of target bird species and to provide a comprehensive list of the avifauna of this SPA.

STUDY AREA

The SPA Sava near Hrušćica with the Rakitje gravel pit (HR1000002) covers the area of 14.53 km^2. It consists of two separate areas, approximately 25 km apart: one part includes the river Sava course (ca 9.5 km in length) immediately downstream of Zagreb, near the settlement of Hrušćica, as well as nearby gravel pits; and the other comprises Rakitje gravel pit, located to the west of Zagreb (Fig. 1). The most important habitats within the SPA include riverbed and gravel pits (19.27% of the area), riparian forests (17.33%), shrubs (30.73%), and arable land (26.82%) (Bioportal 2025). Two gravel pits (Abesinija, Trstenik) are to date actively exploited, while in others (Rakitje, Siromaja), gravel extraction has ceased and are nowadays used for recreational purposes, mostly fishing. Originally designated in 2013 as "Sava near Hrušćica," the SPA covered only the downstream portion of the river, where the river Sava changes its flow from the fast-moving upper reaches to the slower lower flow (Radović *et al.* 2005). This area represents the last remnants of the braided multi-channel river system in a transition zone to a meandering river (Revital 2021). This area hosted natural colonies of Com-

mon and Little Terns. However, following repeated flooding of these colonies in several years, terns abandoned the site. Common Terns established a breeding colony at the Rakitje gravel pit, which became the stronghold of their breeding population in Zagreb area and along the whole river Sava in Croatia (Schwarz 2016). Despite the colony relocation, the Sava near Hrušćica area remains a primary foraging area for Common Terns (Martinović *et al.* 2023). In 2019, the SPA boundaries were modified and extended to include the Rakitje gravel pit and protect both the main nesting and foraging areas of Common Terns.

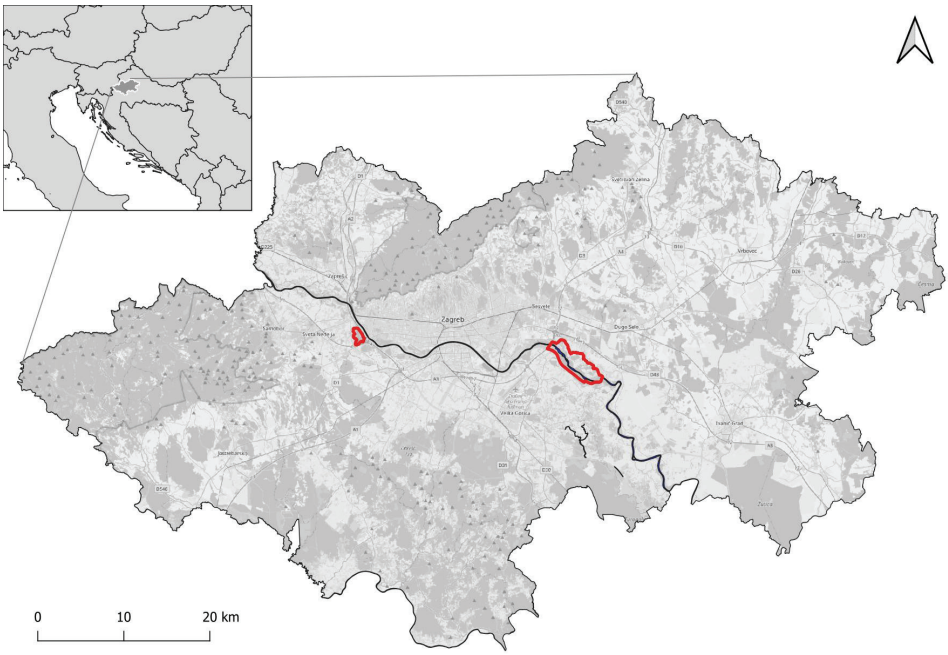

Figure 1 Location of the SPA Sava near Hrušćica with the Rakitje gravel pit (red)
Slika 1. *Položaj POPa Sava kod Hrušćice sa šljunčarom Rakitje (crveno)*

METHODS

Tern monitoring commenced in 2002 (Kralj *et al.* 2019), while counts of other target species began more recently. The two public institutions responsible for the site management, Zeleni prsten Public Institution of Zagreb County and Public Institution Zagreb City Nature have conducted and funded studies and monitoring of target bird species and various management activities. We conducted a study of Rakitje gravel pit avifauna in 2022, while researches on target bird species along the river Sava near Hrušćica area took place in 2023 and 2024. Sand Martin colonies and nests were counted in 2013, 2018, 2023, and 2024, though direct comparison

across years is challenging because of the differences in applied methodology. In 2013 and 2024 all burrows were counted, and the number of active burrows was calculated as a 60% of the total number (Szep 1991). In 2023, both the total number of burrows and the number of apparently occupied burrows (Gilbert *et al.* 1998) were recorded, with the latter used for the population estimate. Wintering waterbirds are counted every January at several gravel pits as part of the International Waterbird Census. The scientific and common names of species follow HBW & BirdLife International (2024) while national Red Data status was taken from Tutiš *et al.* (2013).

RESULTS

A total of 171 species were recorded within the study area, of which 87 were breeding (Supplementary Table 1). Almost half of all species (82 species, 48%) and 30% of breeders (26 species) are associated with wetland or riverine habitats. Of all species, 26 are considered threatened at the national level (Tutiš *et al*. 2013). Breeding populations of four species are classified as Critically Endangered (CR), 12 species are endangered (EN) and 10 are Vulnerable (VU). From all recorded species, 41 species are listed in Annex 1 of the Bird Directive, with five of them (Common and Little Tern, Kingfisher, Common Sandpiper, and Sand Martin) being the target species for this SPA (Table 1).

Table 1. Conservation targets and the current estimated breeding population (in number of breeding pairs), and the percentage of the national population size (according to Dumbović Mazal *et al.* 2019) of the target bird species for SPA Sava near Hrušćica with the Rakitje gravel pit.

Tablica 1. *Ciljevi očuvanja i procijenjena veličina populacija (u broju parova) te udio u nacionalnoj populaciji (prema Dumbović Mazal i sur. 2019) cilnjih vrsta ptica u POP Sava kod Hrušćice sa šljunčarom Rakitje.*

Species	Conservation target	Estimated local population	National population	Percent of national population
Common Tern *Sterna hirundo*	120-150	150-200	400-700	28.5 - 37.5%
Little Tern *Sternula albifrons*	0-20	0	25-60	-
Common Sandpiper *Actitis hypoleucos*	4-5	5-7	160-400	1.8-3.1%
Kingfisher *Alcedo atthis*	1-2	9-12	700-1000	1.2-1.3%
Sand Martin *Riparia riparia*	25-75	155-255	5000-8000	3.1-3.2%

Common Tern *Sterna hirundo*

The Common Tern bred on riverine islands near Hrušćica until 2010, but due to frequent flooding of islands, it started to colonise Rakitje gravel pit in 2004. From 2016 to 2021, the Rakitje colony hosted 90-146 pairs (Table 2). The habitat at the main breeding island at Rakitje gravel pit was managed by regular removal of vegetation. In 2018, a layer of geotextile and 50 m^3 of gravel were added to prevent flooding, while in 2022, additional 8 m^3 of gravel was added. Between 2022 and 2024, due to the high spring water levels and predation by rats, only a small number of terns (up to 40 pairs) attempted to breed, and breeding was mostly unsuccessful. In 2023 an outbreak of highly pathogenic avian influenza (HPAI) caused mortality among Common Terns. At Siromaja gravel pit, a floating breeding platform was built in 2018. Common Terns started nesting there in the same year, and breeding numbers increased annualy, from 26 to 67 pairs in 2023. Breeding has also been occasionaly recorded the gravel pit Abesinija. In some years, a part of the population bred outside the SPA, at gravel pits Čiče, Orešje, and Blato. At Blato gravel pit, 50-120 pairs were recorded between 2006 and 2014. However, since 2014, breeding has only occurred in years with lower water levels. Between 2010 and 2023, the total population in the SPA was estimated at 150-200 pairs, but in 2024, after the avian influenza outbreak, only 26 pairs bred, due to high water levels that prevented breeding on most islands.

Table 2. The number of breeding pairs of Common Terns in the SPA Sava near Hrušćica with the Rakitje gravel pit. + breeding was confirmed, but numbers are not known, * unsuccessful breeding, - no breeding at the locality, empty cells: no data.

Tablica 2. *Broj gnijezdećih parova crvenokljune čigre u POP Sava Sava kod Hrušćice sa šljunčarom Rakitje. + potvrđeno gniježđenje, ali brojevi nisu poznati, * neuspješno gniježđenje, - nije bilo gniježđenja, prazna polja: nema podataka.*

Year	Sava near Hrušćica	Rakitje	Abesinija	Siromaja 2	TOTAL
2002	50		20-25		70-75
2003					
2004	15*	50	10		75
2005	+*	45-50			>50
2006	+*	2*			>2
2007	+	55-60*			>60
2008	+	55-60			>60
2009	70	135			180
2010	30	40			70
2011		30			30
2012	-	50	-		50

2013		30-40			30-40
2014	45	-			45
2015	70	90-95			160-165
2016	50	100			150
2017	-	100-110			100-110
2018	-	106	-	30	136
2019	-	134	-	39	173
2020	-	146	-	54	200
2021	-	103-115	-	57	160-172
2022	-	40	-	65	105
2023	-	21*	-	67*	88*
2024	-	-	-	26	26

Little Tern *Sternula albifrons*

The Little Tern had bred alongside the Common Tern at Hruščica until 2010 with up to 20 pairs. However, the nests, which were often placed very close to the water, were frequently flooded in most years since 2003. Unlike the Common Tern, the Little Tern did not colonise the Rakitje gravel pit after abandoning riverine islands. Only one breeding attempt of a single pair was recorded at Rakitje gravel pit in 2006, and a single individual was observed flying over the lake on 22.5.2011. Additionally, one pair bred at Blato gravel pit in 2008 and 2009. In the last decade, no breeding attempts of the Little Tern have been recorded.

Common Sandpiper *Actitis hypoleucos*

The Common Sandpiper was observed along the river Sava and at Trstenik gravel pit in April, May, and July with 5 and 7 birds recorded in 2023 and 2024, respectively. Although the breeding was not confirmed, single birds were observed in potential breeding habitat. At Rakitje gravel pit, up to five birds were observed from April to November. Breeding was confirmed only in 2012 when one bird with chicks was recorded.

Kingfisher *Alcedo atthis*

The breeding population of the Kingfisher is estimated to 9-12 pairs, with 6-7 along the river Sava, one pair at the gravel pits Trstenik 2 and Siromaja 2, and up to three pairs at Rakitje gravel pit. At Rakitje, it bred near the Sand Martin colonies in 2010 and 2014, while breeding was also recorded in 2017, 2023, and 2024. Densities along the river Sava are between 0.63 and 0.74 pairs/km^2.

Sand Martin *Riparia riparia*

Sand Martins breed along the river Sava, although the location of colonies has shifted over time due to landslides and overgrowing of riverbanks. In some years the main colony was located outside the SPA. For example, in 2013, around 800 pairs were found within the SPA borders and 580 outside of the borders (Mikuska & Grlica 2013). In 2018, only 15-25 pairs were found within the SPA borders, while an additional colony of 75-100 pairs was located about 0.5 km downstream of the SPA boundary. In 2023, 155-175 pairs were counted in five colonies, and in 2024, 225-255 pairs were recorded in four colonies. In 2023, breeding was observed at Trstenik gravel pit in the pile of gravel, where 10 pairs of Sand Martins nested alongside 10 pairs of Bee-eaters *Merops apiaster*. At Rakitje gravel pit, breeding was recorded between 2008 and 2010 and again in 2014 and 2015, with between 30 and 140 pairs nesting in steep, bare banks of the lakes. The highest number of breeding pairs (140) was recorded in 2009.

Apart from the target species, four bird species listed in Annex 1 of the Bird Directive and related to wet habitats breed in the SPA Sava near Hrušćica with the Rakitje gravel pit.

Red-crested Pochard *Netta rufina*

Breeding of the Red-headed Pochard was recorded at Rakitje gravel pit since 2010. Two to three pairs are breeding, with maximum of five males observed in early spring 2023.

Black Stork *Ciconia nigra*

In 2024, three territories along the river Sava near Hrušćica were identified. It is only rarely observed at Rakitje gravel pit.

Little Egret *Egretta garzetta*

A small colony of 7 pairs was established in willows at Rakitje gravel pit in 2023, with the same number breeding in 2024. In both years, one pair of the Grey Heron *Ardea cinerea* bred among them.

White-tailed Sea Eagle *Haliaeetus albicilla*

In 2024, two territories along the river Sava near Hrušćica were identified, but the exact location of the nests was not confirmed. It was regularly observed over the Rakitje gravel pit, from which the closest known nest is at a distance of about 6.5 km.

Low gravel riverbanks and gravel islands represent breeding habitat for other species dependent on wet habitats. The most numerous species are the Black-

headed Gulls *Larus ridibundus* with 20-57 breeding pairs, and the Little Ringed Plover *Charadrius dubius*: in June 2023 almost 50 individuals were counted along the river Sava stretch downstream of Zagreb. Little Ringed Plover was also observed at other gravel pits: Rakitje, Trstenik 2, Trstenik 3, and Abesinija, as well as on gravel surfaces on the Sava embankment. At Rakitje gravel pit, in small reedbed at the edge of island, nesting of Red-crested Pochard, Little Bittern *Ixobrychus minutus*, Mallard *Anas platyrhynchos*, and Mute Swan *Cygnus olor* was recorded. Gravel islands and low river banks are foraging and roosting habitats for storks, herons, waders, and Great Cormorants, the latter gathering in flocks of up to 380 birds. Various waterbirds use open waters (gravel pits and the river Sava) during migration in wintering, but they are mostly present in low numbers. The most numerous are Yellow-legged Gulls *Larus michahellis* (up to 300 individuals), Mallards *Anas platyrhynchos* (up to 200 individuals), Black-headed Gulls (up to 120 ind.), and Coots *Fulica atra* (up to 100 ind.). During migration, up to 1000 Barn Swallows *Hirundo rustica*, 400 Starlings *Sturnus vulgaris*, and 200 Sand Martins *Riparia riparia* are roosting in the SPA.

DISCUSSION

The SPA Sava near Hrušćica with the Rakitje gravel pit covers a small area (representing only 0.08% of the total Croatian SPAs area) but is important for species that inhabit riverine habitats. The most significant population within this SPA is the breeding population of the Common Tern which represents 58.8-69.4% of the total population of this species in the Croatian SPA network (Dumbović Mazal *et al.* 2019).

Established to protect riverine habitats with gravel islands, this SPA encompasses the strech of the river Sava that retains some natural habitat features and the last remaining braided river system on the Sava. However, the river has been altered over the last two centuries to prevent flooding, resulting in the loss of most meanders, branches, shoals, and river islands (Šimunjak 2022). Additionally, upstream hydropower plants in Slovenia significantly impact the river's hydrodynamics. The operation of hydropower plants causes rapid short-term fluctuations in river flow (hydropeaking) and a reduction of gravel sediment transport in the river (Kondolf 1997) that further disrupts sediment balance and riverbed stability (Revital 2021). Furthermore, hydropeaking severely impacts spawning of fish and survival of fish fry and other aquatic fauna (Schwarz 2016) and affects the availability of prey for piscivourous birds. High precipitation during late spring further increases water levels that frequently flood low-lying natural habitats. Frequent flooding of river islands in spring has led to complete breeding failures of tern colonies, which triggered their dispersion (Kralj *et al.* 2019). Gravel pits can offer safer breeding sites for terns, provided that unvegetated gravel islands of adequate height exist, which is rarely the case. Without regular

vegetation removal and gravel supplementation, islands become unsuitable for tern nesting. The breeding island at the Rakitje gravel pit is actively managed to maintain the habitat features required for tern breeding. As high water levels and rat predation prevented nesting at the Rakitje gravel pit between 2022 and 2024, an elevated breeding platform was constructed on the island in early 2025 to ensure better nesting conditions. The breeding platform at Siromaja gravel pit built under the Interreg SI-HR project "Čigra" in 2018 was immediately accepted by breeding terns, with the population reaching 67 pairs before the outbreak of the HPAI.

While Common Terns successfully colonised Rakitje gravel pit, located 25 km from their original breeding location, the Little Tern had disappeared as a breeding species in this area. Common Terns from the Rakitje colony extensively forage in shallow parts of the river Sava near Hrušćica (Martinović *et al.* 2023), and the preference for shallow water was also observed in the Little Tern (Kwaśna *et al.* 2024). The foraging range of the Little Tern is smaller than of the Common Tern (Kwaśna *et al.* 2024) likely limiting its ability to colonise areas distant from preferred foraging area. Thought the Little Tern is known to accept artificial habitats (Scarton 2008, Scarton *et al.* 2013), the breeding platform at Siromaja may have been built too late for them, as the breeding population already disappeared from that area. The Little Tern is also extinct as a breeding species along river Drava in Slovenia, with the last breeding recorded in early 1980s (Škornik 2019).

The Common Sandpiper is the least studied of all the target species. Although regularly observed in the breeding season in suitable habitats, its breeding was confirmed only at the Rakitje gravel pit in 2012. The Common Sandpipers' number can fluctuate annually: in Hungary, a maximum of 2 to 6 birds per 1-km river section was recorded (Hammer *et al.* 2013). More detailed studies along the river Sava are needed. Suitable habitats - low gravel and sand banks with sparse vegetation - should be checked to confirm the breeding and identify breeding success.

Recent population estimates for the Kingfisher and Sand Martin are higher than their respective conservation targets, though their numbers fluctuate depending on habitat availability. Their breeding habitat is threatened by riverbank structural reinforcement along the river Sava outside the SPA, gravel extraction at gravel pits that quickly changes the landscape, and the overgrowth of vegetation, including invasive species such as Bohemian Knotweed *Reynoutria x bohemica*, Wild Cucumber *Echinocystis lobata*, and Common Cocklebur, *Xanthium strumarium* ssp. *italicum* (Buzjak 2018). As with all colonial breeders, Sand Martin numbers may change rapidly, and the loss of unvegetated steep banks would be detrimental to the population within the SPA. The prevention of vegetation overgrowth, removal of invasive species, and eventual re-creation of suitable habitats are possible measures for managing habitats to protect breeding populations of the Kingfisher and Sand Martin.

The breeding population of the Red-crested Pochard represents 7.5-8% of the national population (according to Dumbović Mazal *et al.* 2019), of the Little Egret 1.4-3.9%, the Black Stork 0.9-1.4%, and the White-tailed Sea Eagle 1.3-1.5% These species could be considered for the addition to the target bird species list for this SPA.

Out of the 169 species recorded in the SPA, 26 have an unfavourable conservation status. The majority of them are passage migrants in the SPA, but six Vulnerable species are breeding, including two target species (Common Sandpiper and Sand Martin) and four non-target species for this SPA (Red-crested Pochard, Black Stork, Little Egret, and White-tailed Sea Eagle) are present in low numbers. The Little Tern is listed as Endangered, and despite being designated as a target species, it is no longer present in this SPA.

The SPA Sava near Hrušćica with the Rakitje gravel pit is under strong anthropogenic pressure. Located in a highly urbanized region, it is subject to threats from water pollution (Marinović Ružđjak & Ružđjak 2015), illegal waste disposal, and disturbance from human activities. Hydropower projects at the river Sava upstream of Zagreb present an additional pressure as they would cause further loss of nesting and foraging habitats of the target species (Schwarz 2016). However, new EU legislation, such as Nature Restoration Law, and river restoration plans (Schwarz 2016) present the opportunity to reverse the trends and enable favourable hydrological processes for the target species on the river Sava Revital (2021).

Ornithological studies in this SPA were mainly focused on target species, or birds associated with wet habitats. Therefore, the avifaunal list is not comprehensive, and species inhabiting shrubs, forests, anthropogenic habitats, and nocturnal species have not been studied in detail. Nevertheless, the total number of recorded species and the fact that almost half of all species, as well as 30% of breeding species, are associated with wet habitats highlight the importance of SPA Sava near Hrušćica with the Rakitje gravel pit as nationally important breeding area of threatened bird species. In particular, due to the effective management of tern's nesting habitats by Zeleni prsten Public Institution of Zagreb County and Public Institution Zagreb City Nature, the SPA Sava near Hruščica with Rakitje gravel pit remains to date as the most important breeding area for the Common Tern in Croatia.

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Supplementary Information

The online version contains supplementary material available at https://hrcak.srce.hr/supplement/789

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SAŽETAK

Područje očuvanja značajno za ptice (POP) Sava kod Hrušćice sa šljunčarom Rakitje (HR1000002) jedno je od najmanjih POP-ova u Hrvatskoj. Na području istraživanja zabilježena je ukupno 171 vrsta, od kojih se 87 gnijezdi. Gotovo polovica svih vrsta (82 vrste, 48 %) i 30 % gnjezdarica (26 vrsta) vezano je uz močvarna ili riječna staništa. Ciljne vrste ovog POP-a su crvenokljuna čigra *Sterna hirundo*, mala čigra *Sternula albifrons*, vodomar *Alcedo atthis*, mala prutka *Actitis hypoleucos* i bregunica *Riparia riparia*. Procijenjeni broj gnijezdećih parova za sve ciljne vrste veći je od njihovih odgovarajućih ciljeva očuvanja, osim za malu čigru koja je nestala kao gnijezdeća vrsta s ovog područja. Četiri dodatne vrste ptica s dodatka 1 Direktive o pticama mogu se razmotriti za dodavanje na popis ciljnih vrsta za ovaj POP. Glavne prijetnje su povremena plavljenja otoka za gniježđenje uzrokovana radom hidroelektrana, vađenje šljunka i obrastanje obala vegetacijom, uključujući invazivne vrste. Zbog učinkovitog održavanja gnijezdećih staništa čigri od strane dviju javnih ustanova nadležnih za upravljanje ovim područjem (Javna ustanova Zeleni prsten Zagrebačke županije i Priroda Grada Zagreba), POP Sava kod Hruščice sa šljunčarom Rakitje i dalje predstavlja najvažnije gnjezdilište crvenokljune čigre u Hrvatskoj.