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BREEDING OF THE BROOD PARASITIC COMMON CUCKOO (*CUCULUS CANORUS*) IN REED HABITATS IN NW VOJVODINA, SERBIA

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We monitored the breeding success of the Common Cuckoo (*Cuculus canorus*) in four reed habitats (e. g. clay pits, marsh and fishponds, small canals and large canals) in northwestern Vojvodina (Serbia) between 2009 and 2011 (three breeding seasons). A total of 596 Great Reed Warbler (*Acrocephalus arundinaceus*) nests were found and monitored. The overall parasitism rate for the study area was 0.127, which was calculated from the number of parasitized nests (76) divided by the total number of Great Reed Warbler nests (596). The parasitism rate did not vary with the total number of Great Reed Warbler nests at a study site. The number of parasitized and successful parasitized nests showed significant negative relationship, which means more parasitized nests resulted with more brood lost. The parasitism rate varied significantly among habitats but not among years while the number of successfully parasitized nests differed among both habitats and years. Parasitized nests found in small and large canals showed the highest reproductive success of Cuckoos. Loss of parasitized nests through predation and bad weather circumstances was relatively high in this study compared to other areas.

Key words: brood parasitism, breeding success, survival rate, Kaplan-Meyer survival curve, Great Reed Warbler *Acrocephalus arundinaceus*

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Od 2009. do 2011. godine (tri gnijezdeće sezone) provedeno je istraživanje o uspješnosti gniježđenja obične kukavice (*Cuculus canorus*) na četiri različita trščana staništa (iskopine, močvare i ribnjaci, mali i veliki kanali) u sjeverozapadnoj Vojvodini (Srbija). Parazitiranje kukavice praćeno je u 596 gnijezda velikog trstenjaka (*Acrocephalus arundinaceus*). Stopa kukavičjeg parazitiranja za cijelo istraživano područje iznosila je 0.127, a izračunata je tako što je broj parazitiranih gnijezda (76) podijeljen s ukupnim brojem nađenih gnijezda velikog trstenjaka (596). Pojedinačno po istraživanim lokacijama broj parazitiranih gnijezda nije varirao zajedno s ukupnim brojem gnijezda velikog trstenjaka. Broj parazitiranih gnijezda je bio u negativnoj korelaciji s brojem uspješnih parazitiranih gnijezda, tj. što veći je broj parazitiranih gnijezda, više je propalih. Stopa parazitiranja varirala je značajno između staništa, ali ne između godina, dok je broj uspješno parazitiranih gnijezda značajno varirao između staništa i godina. Parazitirana gnijezda nađena na malim i velikim kanalima su rezultirala s najvišom reproduktivnom uspješnosti kukavice. Broj propalih gnijezda zbog predacije i loših vremenskih prilika u ovom je radu, u usporedbi s rezultatima drugih izvora, relativno visok.

Ključne riječi: parazitiranje gnijezda, uspješnost gniježđenja, stopa preživljavanja, Kaplan-Meyerova krivulja preživljavanja, veliki trstenjak *Acrocephalus arundinaceus*

INTRODUCTION

The Common Cuckoo (*Cuculus canorus*) is a regularly breeding species of the temperate zone of the western Palearctic (Cramp, 1998; Varga, 1998). The bird inhabits almost all habitats except extremely poor mountainous landscapes, dense conifer forests and highly urbanized areas (Cramp, 1998). Cuckoo parasitism has already been recorded in over 100 passerine species (Wyllie, 1975, 1981; Alvarez, 1994; Moksnes & Røskaft, 1995; Cramp, 1998; Honza *et al*., 2001). In the Carpathian basin and in other lowlands, they often parasitize the nests of Great Reed Warblers (GRW, *Acrocephalus arundinaceus*), while in mountain forests, Cuckoos prefer the nests of Robins (*Erithacus rubecula*) for egg-laying (Varga, 1998). The breeding success of Cuckoos in GRW nests depends strongly on the characteristics of the habitat (Moskát & Honza, 2000). One of the relevant factors is the availability of perches (trees or electric wires), which help the adult cuckoos to locate the nests of host species (Moskát & Honza, 2000). The second important factor which affects breeding success is the visibility of the host nests (Moskát & Honza, 2000).

The first study on the breeding success of cuckoos in Serbia was conducted near Apatin (UTM CR 46) between 1981 and 1990 (Lakatoš, 1992). However, that research was conducted only in one breeding site, and it applied a simple methodology while the sample sizes were quite low (Lakatoš, 1992). The first aim of our study was to provide more extensive data on the rate of parasitism of GRW nests and the breeding success of the Cuckoo in Serbia (Fig. 1). Furthermore, we compared Cuckoo parasitism rate, nesting success and chick survival in three years (2009–2011) in four different reed habitats. We specifically tested the hypothesis that parasitism rate and successfully parasitized nests vary across reed habitats and fluctuate among years.

STUDY AREA AND METHODS

Sampling area

The study area was Sombor municipality, which lies on 1,178 km^2 at an elevation of 89 m above sea level (Vojnović, 2001) in the north-western part of Vojvodina (northern Serbia). Sombor is a typical lowland area with a semi-dry continental climate, where the mean annual precipitation ranges between 400 and 900 mm (Đukanović, 1970; Tomić, 1996). In the area of the town of Sombor and its wider surroundings, Cuckoo parasitism is known exclusively from GRW nests in reed (*Phragmites australis*) habitats (Mérő & Žuljević, 2009, 2010). We studied four different reed habitats: clay pits, marshes and fishponds, large canals and small canals. Areas for field surveys were chosen randomly within the habitats (Fig. 1).

a) Clay pits – Reed is usually patchy or fragmented, but dense. The area of water varies strongly. Clay was extracted here for the local brickyards between the 1950s and 1970s.

b) Marsh, fishpond – Marshes are characterized by open (Medura) or closed (Bara Jezero) dense reed stands formed in a long, continuous succession. Fieldwork was conducted on the only large fishpond in Sombor municipality; a fishpond near Kolut (c. 200 ha surface area, and with an inner perimeter of reed at 14.8 km).

c) Large canals – These include wide canals (average c. 25 m) of the Danube-Tisza-Danube hydro-system and a few other bigger canals in Vojvodina. The total length of large canals in Sombor municipality is 114 km. The reed beds of large canals are less dense and their width ranges from two to four meters (Fig. 1, Tab. 1).

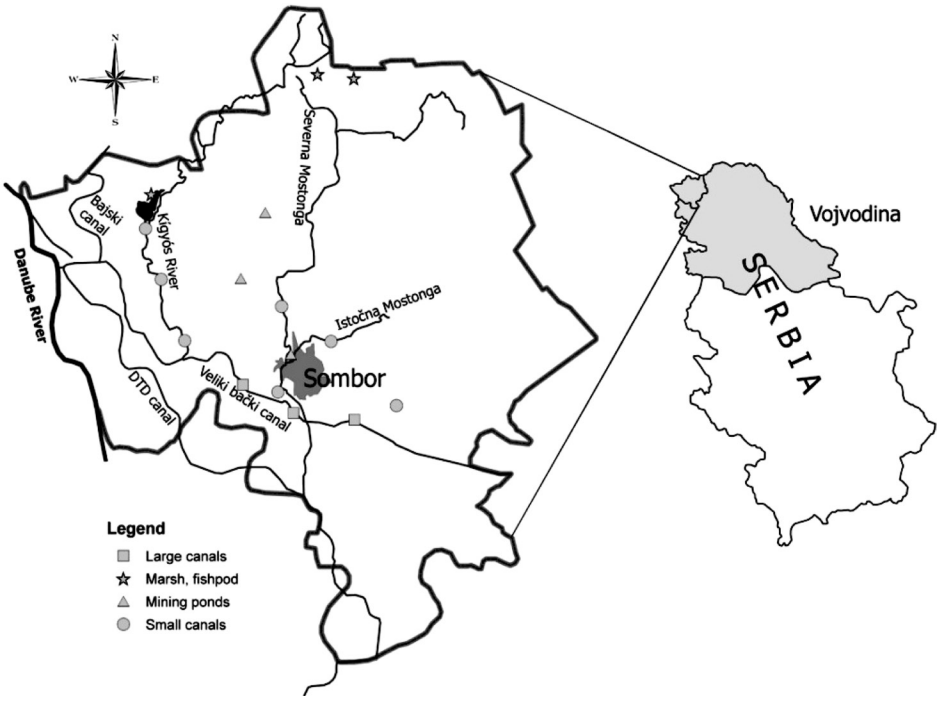

Fig. 1. Location of the study sites in Sombor municipality (NW Vojvodina, Serbia).

c) Small canals – The Detailed Canal Net (Detaljna Kanalska Mreža) contains narrow, small canals belonging to the soil fertility improvement programme. The total length of small canals in the municipality is 821 km. Reed beds are often patchy and are cut after the breeding season.

Methods

GRW nests were surveyed during the entire breeding season which lasted from May to August between 2009 and 2011 at 17 study sites (Tab. 1). We surveyed randomly chosen parts of canals (both sides) and fishponds and marsh, and entire reed beds of the clay pits. After nests were found at a breeding site, they were regularly checked once every five to ten days. During these checks, the number of eggs and nestlings and their changes were registered. We recorded Cuckoo parasitism if a Cuckoo chick was found in a GRW nest. Thus, our measure of the parasitism rate is a minimum estimate because GRW are known to recognize and eject Cuckoo eggs or abandon nests with Cuckoo eggs, which were not counted as parasitized nests in this study. However, rejection of Cuckoo eggs by GRWs was probably rare, as we found less than 10 cases of egg ejection and a similar number of nest desertions in each of the three years of study.

We tested whether Cuckoo parasitism rate and successfully parasitized nests varied by habitat and year in two-way ANOVAs. The parasitism rate was calculated from the number of all GRW nests divided by the number of parasitized nests for all locations and for the three years (2009–2011). Means and standard error were calculated from

Tab. 1. Main characteristics of the study sites.

Habitat	Study area	UTM coordinate	Area surveyed (ha)	Potential perches (distance from reed)
Clay pits	Bager	CR 57 22	1.3	a few solitary trees (5 m)
	Gakovo	CR 58 14	1.4	a few solitary shrubs (5 m)
	Pista	CR 47 88	0.7	surrounded by trees (0 m)
Marsh, fishponds	Medura	CR 59 54	8.4	shrubs (100 m)
	Bara Jezero	CR 59 84	3.0	row of trees (200 m)
	Kolut fishpond	CR 48 14	0.3	solitary trees (50 m)
	Kolut fishpond island	CR 48 14	1.5	solitary trees (220 m)
Small canals	Eastern Mostonga	CR 57 53	0.8	row of trees (35 m)
	Northern Mostonga	CR 57 16	0.9	trees and shrubs (0 m)
	Stara Mostonga	CR 56 19	0.9	several shrubs (0 m)
	Kiđoš Kolut	CR 48 02	1.1	a few solitary trees (0 m)
	Kiđoš Bezdan	CR 47 18	0.7	a few solitary trees (0 m)
	Kiđoš B. Monoštor	CR 47 33	2.4	orchard (40 m)
	Gradina lat.	CR 66 27	0.2	a few solitary shrubs (5 m)
Large canals	VBK Lugovo	CR 56 76	2.5	forest belt (5 m)
	VBK Sombor	CR 56 18	13.0	forest belt (5 m)
	VBK Šikara	CR 46 89	3.7	forest belt (5 m)

these rate values for each habitat (Fig. 2). We compared differences in means among groups by Tukey's HSD test. We also used linear regression to test the relationship between the number of GRW nests and Cuckoo parasitism rate, as well as between parasitism rate and Cuckoo breeding success (successfully parasitized nests, *i.e.* nests in which Cuckoo nestlings successfully fledged out). We applied parametric tests only if the assumptions of such tests were met by the data. Due to the non-normality of distance data, we used Spearman's rank correlation to check if parasitism rate varied with distance to perches. The Kaplan - Meyer survival analysis was used to compare the survival of Cuckoo chicks in GRW nests during the three years. All statistical analyses were calculated in the R statistical environment (version 2.13.0, R Development Core Team, 2011) or with the *SPSS* statistical software package (survival analyses).

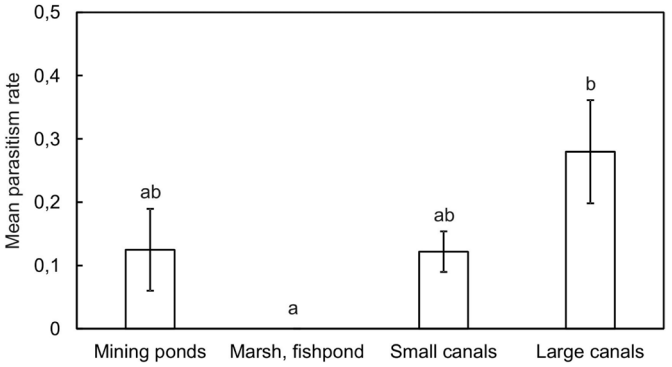

Fig. 2. Mean number of Cuckoo fledglings in the four different habitats (summarized for all three years). Different lowercase letters indicate significant differences between the columns (Tukey's HSD test, $p < 0.05$).

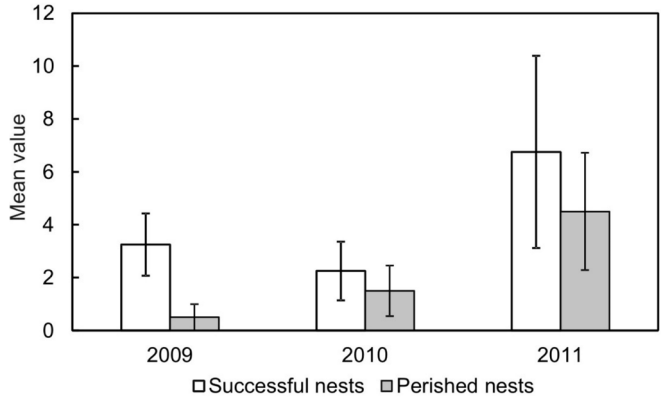

Fig. 3. Mean number of Cuckoo fledglings (open bars) and perished individuals (shaded bars) within three years summarized for all habitats.

RESULTS

We found and monitored a total of 596 GRW nests (2009: 131; 2010: 250; 2011: 215) between 2009 and 2011. From the total of 596 GRW nests, 12.7% (76 nests) were parasitized. Successful Cuckoo breeding was recorded in 65.8% of these nests (50 nests, Tab. 2).

The rate of parasitism by Cuckoos did not vary with the total number of GRW nests at a site (linear regression, $F = 0.611$, $df = 41$, $p = 0.434$). The distance of perches was not significantly correlated with parasitism rate (Spearman's rho = –0.39, $p = 0.126$). However, the relationship between parasitism rate and Cuckoo breeding success was negative ($B = –0.052 \pm 0.022$, $F = 5.747$, $df = 21$, $p = 0.026$).

In testing the hypothesis that Cuckoo parasitism rate and successfully parasitized nests vary by habitat and year, we found that the parasitism rate differed among habitats

Tab. 2. Nesting success of Cuckoo between 2009 and 2011 (NW Vojvodina)

Habitat	Locality	Number of GRW nests	Parasitized nests (N)	Successful parasitized nests (N)	Density of parasitized nests per year (ha^{-1})
Clay pits	Bager	73	0	0	0.0
	Gakovo	74	1	1	0.7
	Pista	17	6	4	8.6
Marsh, fishpond	Medura	6	0	0	0.0
	Bara Jezero	8	0	0	0.0
	Kolut fishpond	10	0	0	0.0
	Kolut fishpond island	2	0	0	0.0
Small canals	Eastern Mostonga	45	16	9	20.0
	Northern Mostonga	25	4	2	4.4
	Stara Mostonga	13	2	2	2.2
	Kigyós Kolut	47	1	1	0.9
	Kigyós Bezdan	38	3	2	4.3
	Kigyós B. Monoštor.	75	5	3	2.1
	Gradina lat.	35	3	3	15.0
Large canals	VBK Lugovo	28	9	8	3.6
	VBK Sombor	72	21	11	1.6
	VBK Šikara	28	5	4	1.6
Total		596	76	50	–

(two-way ANOVA, F = 3.732, df = 3/38, p = 0.019), and proved to be marginally non-significant by year (F = 3.080, df = 1/38, p = 0.087). We revealed the highest difference between large canals and marshes regarding parasitism rate (27% and 0% in large canals and marshes, where no parasitized nests were found, respectively) (Fig. 2). The maximum number of Cuckoo eggs found per nest was three (in a nest also containing four GRW eggs), while, in two cases, we found two young Cuckoo nestlings together in one nest.

In contrast, successfully parasitized nests did not vary among habitats or by years (habitat F = 0.277, df = 2/19, p = 0.761; year F = 1.894, df = 1/19, p = 0.185), although it was similarly higher in small and large canals than in clay pits (Fig. 3) and it was non-significantly higher (only c. 15% of chicks perished) in 2009 than in the other two years (c. 66% chicks, Fig. 3). From the total number of parasitized nests, 34.2% were lost (Tab. 2). Most of parasitized nests were destroyed by predators (84.7%), and in 2010, two almost fledged Cuckoo nestlings were destroyed by stormy weather.

The average breeding density per hectare was 1.0 pairs in clay pits, 0.0 pairs in marshes and fishponds, 1.0 pairs in small canals, and 1.8 pairs in large canals.

The survival rate of Cuckoo nestlings did not differ significantly among the years (2009-2011, log rank test, $\chi^2 = 4.96$, df = 2, p = 0.084). Survival decreased abruptly only after day 10 in 2010, indicating that older nestlings perished (Fig. 4).

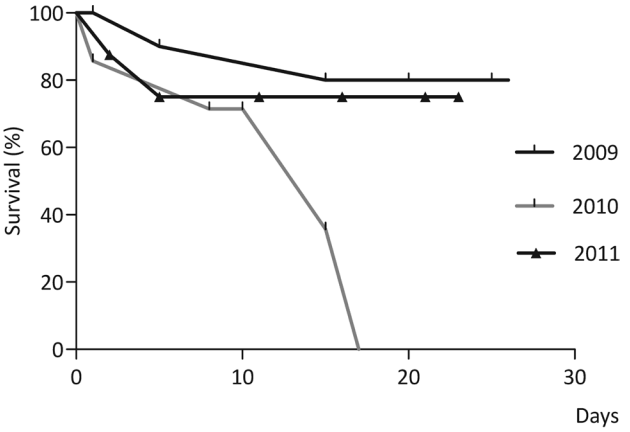

Fig. 4. Kaplan – Meyer curves in survival of Cuckoo eggs and nestlings, 2009-2011.

DISCUSSION

We recorded the highest number of parasitized nests in small and large canals (Tab. 2), and the rate of Cuckoo parasitism was independent of the number of GRW nests at a site. However, studies conducted on the Reed Warbler (*Acrocephalus scirpaceus*) (Stokke, 2007) and Robin (Varga, 1994) found strong positive relationships between the number of host and parasitized nests. The frequency of parasitized nests in our study was 12.7%, which is relatively low compared to that found by Bártol *et al*. (2003) who mentioned that brood parasitism can locally exceed 50%. Varga (1994) also recorded higher (31.6%) brood parasitism in Robin populations than that found here. Lakatoš (1992) reported an average Cuckoo parasitism on GRW nests of 16.7% for a 10-year period, which is similar to our results. In our study, the distance of perches did not significantly influence parasitism rates. In contrast, Hungarian studies reported that the distance of the perches significantly affects Cuckoo parasitism on GRW nests (Moskát & Honza, 2000).

Hungarian studies reported that the hatching rate of Cuckoos was higher when more than one eggs were laid per GRW nest (multiply parasitized nests) (Moskát *et al*., 2009). However, nestling survival was higher in single parasitized nests. For example, Moskát *et al*. (2009) reported that 93% of hatched nestlings became fledglings in single parasitized nests; while this value for the eggs in multiply parasitized nests was lower (75%). Our results showed generally much lower values (successful: 65.8%). It is possible that predation is stronger in our study sites, but we also have to consider the effect of the cold, rainy weather in 2010. We assume that the most frequent predators of Cuckoo

nestlings (excluding clutches in the egg stage) were Night Herons (*Nycticorax nycticorax*) and Little Bitterns (*Ixobrychus minutus*), which were often observed in our study sites, sometimes during the destruction of non-parasitized GRW nests (T.O.M., *pers. obs.*). Furthermore, a Spanish study reported that competitor Cuckoo individuals are also able to destroy Cuckoo eggs or nestlings (Alvarez, 1994). The study conducted near Apatin reported a breeding success of 93.7% (Lakatoš, 1992), which is similar to the results of Moskát *et al*. (2009). In our study the proportion of successfully parasitized nests was lower (65.8%) because we considered the breeding success of 17 localities (four habitats), where the loss of Cuckoo nestlings varied between 28.6% and 35.5%. In the studies by Lakatoš (1992) and Moskát *et al*. (2009) all the research was done at one location.

The size and pigmentation of a Cuckoo egg are very similar to those of the eggs of GRWs. This level of adaptation is also an explanation for the high success of Cuckoo parasitism. However, the nesting success of the Cuckoo strongly depends on how often the hosts, GRWs, recognize the eggs and eject them from the nests (Molnár, 1944). After hatching, the Cuckoo nestlings evict host eggs or nestlings from the nests (Molnár, 1944; Varga, 1994). Besides host egg rejection behavior, predation also strongly influences nesting success of Cuckoos (Alvarez, 1994; Moskát *et al*., 2009). Furthermore, we recorded that weather conditions may also affect the survival of nestlings (observed in 2010). Under harsh weather conditions the timing of breeding of GRWs is also negatively affected and in many cases the nesting season lasts longer (e.g. until mid-August in 2010). It is well-known that Cuckoos do not lay eggs so late in the season (Varga, 1994).

According to our results we conclude that brood parasitism in our study area is relatively low compared to that revealed by other studies. We found that the number of GRW nests did not affect the frequency of parasitism, but the relationship between the number of parasitized and successfully parasitized nests was significantly negative, meaning that higher rate of parasitized nests resulted in more lost broods. According to our results the best reed habitats for Cuckoo parasitism in Vojvodina are small and large canals. In light of the hypothesis we conclude that Cuckoo parasitism rate differs among habitats, but it does not fluctuate among years. Furthermore, the breeding success of the Cuckoo *i.e.*, nestling survival varies insignificantly over habitats and years.

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