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Differences in eggshell pigmentation pattern between Common Moorhen *Gallinula chloropus* and Eurasian Coot *Fulica atra* eggs

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Abstract Facultative avian brood parasites increase their reproductive output by laying eggs in the nests of conspecifics or closely related species. The Common Moorhen *Gallinula chloropus* is a well-known facultative brood parasite that nests in wetlands, which are utilised also by a wide range of waterfowl, including the Eurasian Coot *Fulica atra*. The two species breed in similar habitats and have a similar egg pigmentation pattern; thus, the Coot can be a suitable host of brood-parasitic Moorhen. To study whether there is any discernible difference between the spotting pattern of Coot and Moorhen eggs, we compared the density of different sized spots on eggs of the two species. Our results show that Coot eggs have a significantly higher density of small speckles then Moorhen eggs, while the latter species has eggs with more conspicuous larger spots. Therefore, Coots can possibly rely on these differences in eggshell pattern to recognize and eject the brood parasitic Moorhen eggs.

Keywords: aquatic birds, interspecific brood parasitism, egg morphology, Rallidae

Összefoglalás A fakultatív költésparazita madárfajok növelhetik szaporodási sikerüket azáltal, hogy tojásaik egy részét azonos vagy közelrokon fajok fészkébe tojják. A vizes élőhelyeken fészkelő vízityúk *(Gallinula chloropus)* egy közismert fakultatív költésparazita, amely néha a szárcsát *(Fulica atra)* is parazitálja. A két faj hasonló élőhelyen költ, és hasonló tojásmintázattal rendelkezik, így a szárcsa kézenfekvő gazdafaj lehet a vízityúk számára. Összehasonlítottuk a két faj tojásain található, különböző méretű foltok gyakoriságát azért, hogy megvizsgáljuk, van-e olyan észlelhető különbség a tojásaik mintázata között, amely révén a szárcsa felismerheti a fészekidegen tojásokat. Eredményeink azt mutatják, hogy a szárcsa tojásai jelentősen sűrűbben szeplőzöttek a vízityúkénál, míg utóbbi tojásain, gyakrabban előfordulnak szembetűnőbb, nagyobb foltok. A tojások mintázatbeli különbsége lehetővé teheti a szárcsa számára, hogy felismerje a vízityúk tojásait, és elkerülje a költésparazitizmussal járó költségeket.

Kulcsszavak: vízi madarak, fajok közötti fészekparazitizmus, tojás színezet, guvatfélék

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Introduction

Brood parasitism is a reproductive strategy found across a wide range of avian taxa (Haraszthy 2019a, b), in which females lay their eggs in the nest of conspecific or heterospecific hosts, with the aim of increasing their own reproductive output on the expense of the hosts' parental care directed towards the host's own brood (Davies 2000). While only 1% of all avian taxa are obligate brood parasites (i.e. rely solely on the parental care of heterospecific hosts), conspecific brood parasitism is a facultative strategy, and it is more common in precocial species (e.g. around 60% of all Anatidae species, Yom-Tov & Geffen 2018). Common Moorhens *Gallinula chloropus* (Moorhen hereafter) exhibit a highly diverse breeding strategy, ranging from monogamy to polygamy and polygyny, but are also notoriously brood parasitic (Gibbons 1986). Moreover, besides eggs dumped in the nests of conspecifics, Moorhen eggs were found within the clutches of Little Bittern *Ixobrichus minutus*, Eurasian Coot *Fulica atra* (Coot from hereafter), Grey Partridge *Perdix perdix*, Little Grebe *Tachybaptus ruficollis*, Black-headed Gull *Chroicocephalus ridibundus* and Ferruginous Duck *Aythia nyroca* (Engler 1983, David *et al*. 2005, Meniaia *et al*. 2014, Haraszthy 2018).

The nestlings of precocial species do not rely as heavily on the care of their parents (or foster parents) as altricial nestlings do, however, increased number of eggs in the nest might lead to nest destruction (Wang *et al.* 2013) or lower fledgling success (Lyon 1993, 2003). For example, in the Moorhen population studied by Gibbons (1986), the mean number of nestlings successfully reared from nests containing eggs from only one female was 1.70, while only 1.20 nestlings fledged from the nests containing the eggs of multiple females. Therefore, hosts are expected to evolve defences to minimize the occurrence and negative effect of brood parasitism, by recognizing the parasites as enemies, or by recognizing and rejecting brood parasitic eggs (Davies 2000).

After finding a seemingly rejected Moorhen egg next to a clutch of Coot eggs, we decided to investigate whether the differences in eggshell pigmentation may constitute reliable cues for the Coot in the recognition and rejection of Moorhen eggs. We hypothesise that there are some subtle differences in the eggshell pigmentation that enable Coots to recognize foreign eggs, thus evading brood parasitism. Coot and Moorhen eggs are fairly similar in size and shape, and have fine speckles and brownish blotches of various sizes on a white-ivory background. We predict that the density of fine speckles is higher on Coot eggs, while in contrast, the density of larger blotches is higher on Moorhen eggs.

Materials and methods

The Eurasian Coot is one of the most abundant species at our study site Câmpenești fishponds, Romania (46°50'35.7"N 23°42'23.1"E), where it reproduces in large numbers despite the intense human activity around the fishpond, and forms relatively abundant flocks in winter (Kiss & Pripon 2019). Here, we found a seemingly rejected Moorhen egg next to a Coot nest containing 8 eggs in 2018. In order to quantify the differences in eggshell

pigmentation, we conducted spot counts based on spot size, on Coot eggs from different nests from our study site ($n = 5$) and Moorhen eggs ($n = 5$). To have an identical sample size between the two species, besides the Moorhen egg found next to the Coot nest in 2018, we sampled four locally collected Moorhen eggs in the oological collection of Zoological Museum of the Babeș-Bolyai University.

We classified the markings on the eggs based on the diameter of the spots on the eggshell, as follows: "speckles" (< 0.5 mm), "small spots" (0.5–1 mm), "large spots" (1–3 mm) and "blotches" (>3 mm). We photographed 6 squares on each egg through a handheld magnifier glass (5× magnification) and direct visually counted the spots of different sizes. Thus, we evaluated the number of spots on 30 squares collected from Coot eggs and 30 squares collected from Moorhen eggs, and calculated their average number and relative frequency. Large spots and blotches scarcer and more dispersed then speckles and small spots, therefore are better evaluated by relative frequency within the randomly selected squares. Both evaluations reflect the density of spots on the eggshell surface.

We performed One-way ANOVA analysis using PAST programme in order to test difference between the egg markings of the two species.

Results

Although Coot and Moorhen eggs have a highly similar eggshell pigmentation pattern, we found marked differences in the abundance and relative frequency of different sized spots between the eggs of the two species *(Table 1)*.

Coot eggs had on average more speckles then Moorhen eggs ($F = 297.20$, $df = 33.54$, $P < 0.001$), while Moorhen eggs had a higher abundance of small spots ($F = 10.72$, $df = 46.31$, $P = 0.002$) and blotches ($F = 13.42$, $df = 33.83$, $P < 0.001$). We found no significant difference in the abundance of large spots (i.e. spots of 1–3 mm diameter) between the two species ($F = 2.06$, $df = 56.36$, $P = 0.157$).

Table 1. Minimum, maximum, mean (± *SD*) number of each type of spots per evaluated square (25 mm^2), and the relative frequency (*F%*) of each type of spots on Coot and Moorhen eggs

1. táblázat Különböző méretű foltok relatív gyakorisága (*F%*), illetve minimum, maximum és átlagos (±*SD*) száma 25 mm^2-es mintavételezési négyzetekben, szárcsa és vízityúk tojásokon

	Speckles		Small spots		Large spots		Blotches	
	Coot	Moorhen	Coot	Moorhen	Coot	Moorhen	Coot	Moorhen
Min	72	12	0	0	0	0	0	0
Max	185	40	4	9	4	2	1	3
Mean ±SD	111.06 ±27.12	22.40 ±7.61	1.66 ±1.44	3.40 ±2.51	0.53 ±0.97	0.86 ±0.81	0.10 ±0.30	0.83 ±1.05
F%	100%	100%	60%	90%	30%	60%	10%	46%

Discussion

The recognition of brood parasitic eggs by hosts, based on the eggshell markings is a widespread and well-studied host defence (Davies 2000). Host that fail to recognize foreign eggs and act on it accordingly, are compelled to invest parental care in non-kin offspring at the detriment of their own offspring (Lyon 2003, Wang 2013).

We found marked differences between the eggshell pattern of the facultative brood parasitic Moorhen and its occasional host, the Eurasian Coot. Therefore, our results provide evidence that Coots could rely on the differences in eggshell pigmentation to recognize foreign eggs and evade the costs of brood parasitism. The recognition of own eggs might be particularly important in this species, because besides facing the odds of the occasional interspecific brood parasitism of the Moorhen, the Coot is also known to utilize this alternative reproductive strategy as a facultative intra- and conspecific brood parasite (Samraoui & Samraoui 2007, Haraszthy 2018).

The American Coot *Fulica americana* is known to count its eggs and to recognize if there are extra eggs in its clutch (Lyon 2003), however, it is not known if this frontline defence is shared with its sister taxa, the Eurasian Coot.

If the Eurasian Coot is capable of true egg recognition (*sensu* Lyon 2007), the occurrence of intraspecific or conspecific brood parasitism might be higher than reported in previous studies, since hosts might immediately recognize and remove foreign eggs from the clutch. Further studies are needed to assess the extent and costs of Moorhen brood parasitism on Coots, alongside an experimental framework for testing the underlying mechanisms of brood parasitic egg recognition by Coots. However, since a closely related species showed marked egg recognition abilities during experimental egg-swaps (Lyon 1993, 2003, 2007), it is worth mentioning that for such experiments freshly collected Moorhen eggs are needed, to exclude the confounding effect of other egg recognition cues (e.g. surface ruggedness of clay eggs, low weight of eggs from oological collections etc.).

We conclude that the eggshell pigmentation patterns can serve as reliable cues for the Coot to recognize its own eggs and spot foreign eggs within its clutch, thus evading the costs posed by brood parasitism.

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