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Forage, preen or fight? A study of interspecific water bird interactions at Crișul Repede River

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Abstract. Analyzing the behavior of birds offers insight into the conservation of biodiversity, a heavily discussed subject in the fields of ecology as well as ornithology. As it has been previously proven (Rushton *et al.*, 1994), slow-flowing areas of rivers represent important habitats for birds all throughout the year and the conservation of this type of habitats has been known to have a positive effect on the population of many water bird species (Rolls *et al.*, 2012). Therefore, this study explores the dynamic of interspecific interactions between water birds in open water areas from the Afon Peța portion of the Crișul Repede River in Bihor, Romania. We collected data over 8 months, from October 2022 to May 2023 and identified 23 bird species and three types of interactions between them: cooperation for foraging, for grooming, and aggression. The frequency of various interactions was directly proportional to the number of individuals observed on the area, however, we found no connection to the month or the season. Additionally, we detected no preference regarding the interaction partner species. We found a strong correlation between the number of individuals and the number of interactions in all species. The results obtained through this study will help broaden the knowledge about common aquatic bird species in the area, as well as the dynamic of behaviours over the course of three seasons.

Keywords: aggression, cooperation, Crișul Repede River, interspecific behaviour, water birds.

Introduction

Birds have been an object of fascination for people for centuries, as evidenced by Aristotle's belief that Redstarts become Robins as soon as winter begins (Lohmann, 2018). Since the debut of experimental work conducted on birds in the late 1800's (Birkhead & Charmantier, 2009), the number of published studies has been increasing exponentially (Bibby, 2003), many conservation biologists using them as great indicators for assessing the state of the environment (Grimes, 2005). Along with the appearance of ornithology came animal behavior, with pioneers such as C. Lloyd Morgan and Tinbergen publishing their work (Birkhead & Charmantier, 2009). The study of behavior in animals has been a crucial tool in conservation biology by allowing us to predict migrations (Chapman *et al.*, 2011) and the spread of invasive species (Cote *et al.*, 2010), one study focusing on developing a distribution model of bird populations in regard to interspecific interactions (Zurell, 2017). This type of behavior refers to a form of communication between two individuals from different species (Dhondt, 2012; Abrams, 2001), yet they are often short in duration and difficult to observe in nature and, as a result, there is a general lack of studies in this area.

The conservation of riverine habitats has been tightly linked to many benefits for humans and ecosystems alike; we can only benefit from regulating and cultural ecosystem services if we maintain the habitat quality (Arthington *et al.*, 2009). By preserving riverine habitats, we are ensuring connectivity between the habitats, as well as refugia for many species (Rolls *et al.*, 2012). Slow-slowing rivers play a crucial part in regulating nutrient cycling and sediment transport, all of which contribute to increasing biodiversity in freshwater ecosystems (Tickner *et al.*, 2020).

The purpose of this paper is to explore the dynamic of the interspecific interactions within water bird communities during passage and wintering seasons. In this context, the aims of our study were: i) the identification of interspecific interactions in the observed species, ii) the analysis of interspecific interactions in relation to the observation period and the qualitative and quantitative dynamics of avifauna.

Materials and methods

Study area

The Crișul Repede River's spring is in the Gilăului Mountains in the Apuseni Mountains (N-W Romania). It belongs to the hydrographic network of the Tisa River, forming the big three Crișuri rivers after which the Crișana area was named, along with the Crișul Alb and Crișul Negru rivers (Telcean *et al.*, 2007). The Crișul Repede river that flows throughout the Apuseni Mountains is passing through Dealurile de Vest and Câmpia de Vest (Posea, 1977). Therefore, the drainage slope varies from steep in the mountain region to a very gentle one in the vicinity of Oradea (Măhăra, 2010). Here, the river meanders and the waterflow slows down, creating lakes such as the Afon Peța Lake (Blaj *et al.*, 1979) (Fig. 1).

Figure 1. Map of the study area showing Afon Peța lake with four observation points (Google Earth image generated at 07.09.2023)

The studied area is situated in the Sântion town from Bihor county, next to Balta Sântion, a fishing pond. The portion has been analyzed from 4 observation points (**Fig. 1**), depending on the visibility and presence or absence of the species. The observation area has a surface of 55 m^2 and has a perimeter of approximately 1,39 km; the observation points were chosen in order to maximize visibility over the water surface. Near the river bank, there is a patch of reed that is used by the birds as a refuge, covering about 5% of the study area. Surrounding the Crișul Repede, some *Rosa canina* bushes can be found, separating the agricultural corn fields from the river, as well as meadows that locals use for cattle grazing.

Sampling

For data collection, 51 single visits have been made in the Afon Peța part of the Crișul Repede river, for which the following materials have been used: an observation sheet for each visit, Vortex Diamondback HD 8x42 binoculars, Canon PowerShoot ZOOM monocular camera, ornithological identification guide (Svensson, 2009). The data was collected in 2 sessions, one in the morning (anywhere between 08-11) and one in the afternoon (between 13-16).

Each monitoring visit began with a water bird species inventory from the studied area, followed by the counting of individuals in each species. An ethogram was completed over the course of 60 minutes, following the direct observations, the species and their behaviors observed being written on the sheet along with the meteorological, and date and time aspects. The interactions fit into one of the two categories: aggression (A) or cooperation, the latter being divided into cooperation for feeding (CoF), CoG (for grooming), CoA (for attack), and CoD (for defence). In order to collect the data, we have organized four field visits per month, of which two in the morning and another two in the afternoon, the study taking place from October 2022 to May 2023.

A series of criteria was taken into consideration for an interaction to be placed into a category. For instance: aggression (A) implies that an individual will stake an attack stance (by raising their wings, extending the neck towards the enemy, and opening the bill). Cooperation for feeding (CoF) takes place when two individuals from different species are feeding simultaneously in close proximity to one another, similar to the grooming cooperation (CoG). For cooperation for attack (CoA) to take place, multiple species must aggress, at the same time and place, another species. For an interaction to be considered cooperation for defence (CoD), it has to imply an attack on another species, and a counterattack response from individuals that belong to another species than the aggressed one.

Data analysis

Bird interactions were recorded as interaction counts. We summarized the number of all interactions per species over 8 months of observations. We classified the types of interactions into the four observed categories: aggression (A), Cooperation for feeding (CoF), Cooperation for grooming (CoG), and Cooperation for aggression (CoA). Additionally, we categorized species into "instigator" and "reactor" depending on the role they assumed in the interaction behavior.

To check for differences between species, we computed the percentage of interactions per species and the role (instigator/reactor) in which they were observed. We also computed the percentage of interactions per type of interaction with other present species in each species that interacted the most. Interaction preference was tested only in the case of those species that significantly interacted more than others due to the larger number of values for interaction counts usable in statistical tests. Data was checked for normal distribution with the help of the Shapiro-Wilk test. For non-normally distributed data, we used the Kruskal test to check whether there are significant differences, followed, in case of significant results, by a Dunn post-hoc test with Benjamini-Hochberg adjusted p-values. We also performed a correlation analysis between the two components of interactions (instigation/reaction) and between the number of individuals and the number of interactions by using Spearman's rank correlation test. All data analyses were performed in RStudio (Posit team, 2024).

Results and discussions

During the study period, there have been observed a total of 23 species of birds (Table 1). In order to assess the species' dynamic, their monthly presence was noted, with the highest number of species per month appearing during April, with 18 species (Fig. 2). One possible explanation for the large number of birds during April 2022 (which represents the period between the cold and warm season) is the overlap (partially or completely) of migratory periods, the numbers of migratory populations being cumulated with those of sedentary populations (Dimitrie, 1984). The second most prolific month was January, with 13 observed species, closely followed by November with 12 bird species that spend winter in the slow-flowing rivers of Bihor. During October, February, March and May, 11 species inhabited the area, with the lowest number registered being recorded in December. The lack of diversity during these months is likely due to the competition between species, caused by limited sources of food, which leads to the maximizing of survival chances of the existing species (Dhondt, 2012).

Table 1. A complete list of species present during the study, including the shortened version of the names used during the statistical analysis.

Name of the species	Code
Actitis hypoleucos	Acti hypo
Anas penelope	Anas pene
Anas platyrhynchos	Anas plat
Anas querquedula	Anas quer
Anser fabalis	Anse faba
Ardea alba (Casmerodius albus)	Casm albu
Ardea cinerea	Arde cine
Aythya ferina	Ayth feri
Aythya fuligula	Ayth fuli
Chroicocephalus ridibundus	Chro ridi
Cygnus cygnus	Cygn cygn
Cygnus olor	Cygn olor
Egretta garzetta	Egre garz
Fulica atra	Fuli atra
Gallinula chloropus	Gall chlo
Himantopus himantopus	Hima hima
Larus michahellis	Laru mich
Nycticorax nycticorax	Nyct nyct
Phalacrocorax carbo	Phal carb
Podiceps cristatus	Podi cris
Sterna hirundo	Ster hiru
Tachybaptus ruficollis	Tach rufi
Vanellus vanellus	Vane vane

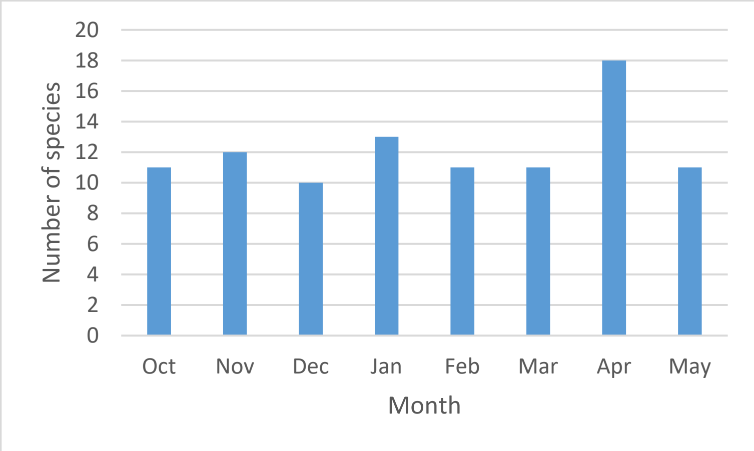

Figure 2. The species' dynamic over the course of 8 months.

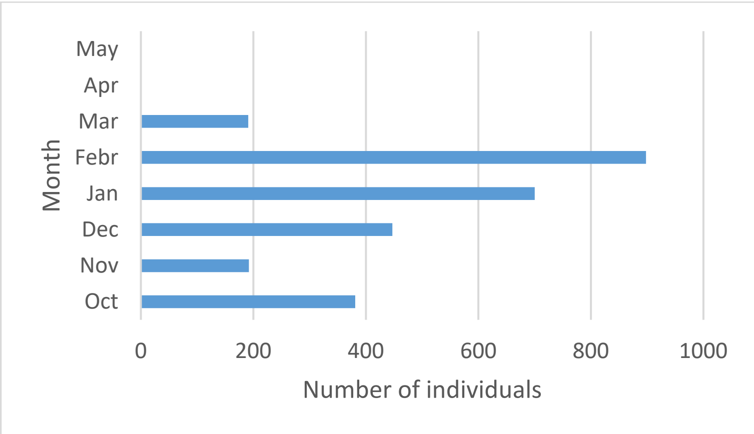

Figure 3. Numerical evolution of the Eurasian Coot population.

Out of the 23 species, three have been consistently present in the study area, with the most abundant being the Eurasian Coot (*Fulica atra*), 168 individuals being observed in one visit. The Black-headed Gull (*Chroicocephalus ridibundus*) is remarkable in numbers due to it having the largest number of individuals/species in one sitting (180 individuals). The third most notable species is the Tufted Duck (*Aythya fuligula*) with 32 birds observed at one time. Nevertheless, the Eurasian Coot population numbers have decreased drastically since February (Fig. 3); the Black-headed Gulls have presented a consistent numerical decrease over the entire course of the study (Fig. 4). Contrary to the coots, the Tufted Ducks have made their debut to Afon Peța in December and had an exponential growth until their decline in May, when no individuals were observed (Fig. 5). However, such changes in the number of individuals may also be due to the expected fluctuations in food over time (Keller *et al.*, 2009).

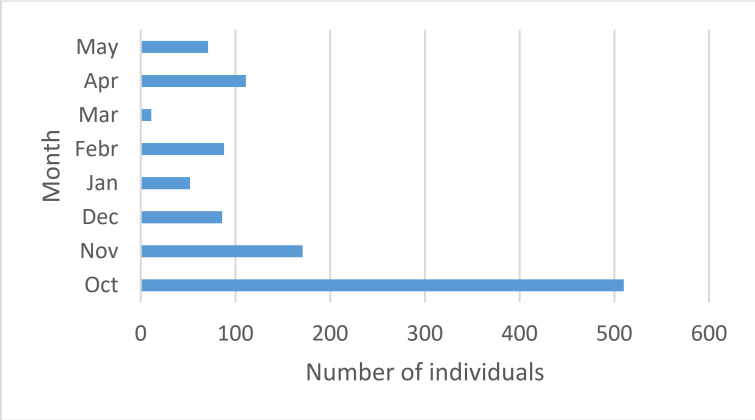

Figure 4. Numerical evolution of the Black-headed Gull population.

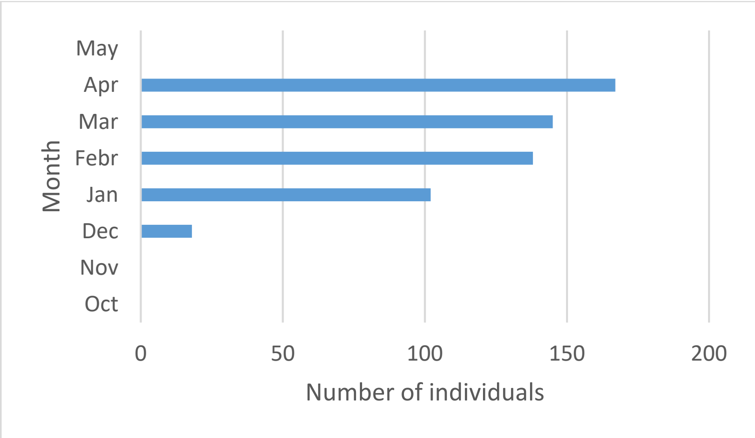

Figure 5. Numerical evolution of the Tufted Duck population.

There are two major limiting factors to be taken into consideration when analyzing animal behaviours: space and food availability. As the density of individuals increases, the average reproductive rate will decrease; it has also been shown that habitat heterogeneity within the territories occupied by individuals will affect each individual differently, therefore the species that compete for a territory will vary (Dhondt *et al.*, 1992; Ferrer *et al.*, 2006, Martinez *et al.*, 2008). Food is a limited resource during the wintering season, which incites interspecific competition, having effects on the survival of individuals and implicitly on the size of the population that can reproduce (Dhondt, 2012). The bird species present in the area are part of different feeding guilds depending on the water depth at which they feed; in this context, surface-level feeders are terns and gulls, shallow water feeders are herons, egrets and Mallards, with the diving species observed being cormorants, the Tufted Duck, Common Pochard and the Eurasian Coot (Liordos & Kontsiotis, 2020). Thus, the feeding cooperation between several species which have different niches presents numerous benefits for birds, such as reducing the risk of predation, which has been studied by several authors (Lima, 1986, 1993; Pulliam and Caraco, 1984). An indirect result is reduced individual vigilance due to the safety provided by the group, which explains an increase in feeding rate (Beauchamp, 1998).

Of the 23 species observed, only 17 manifested interspecific interaction behaviors with other bird species. The Eurasian Coot and Tufted Duck represented the species with the most observed total interactions, manifesting three of four interaction types. At the same time, the Black-headed Gull and Yellow-legged Gulls (*Larus michahellis*) were the species where we observed all four interaction types (Fig. 6). The Little Egret (*Egretta garzetta*) and the Grey Heron (*Ardea cinerea*) were observed to interact very rarely and only with one interaction type (Fig. 6).

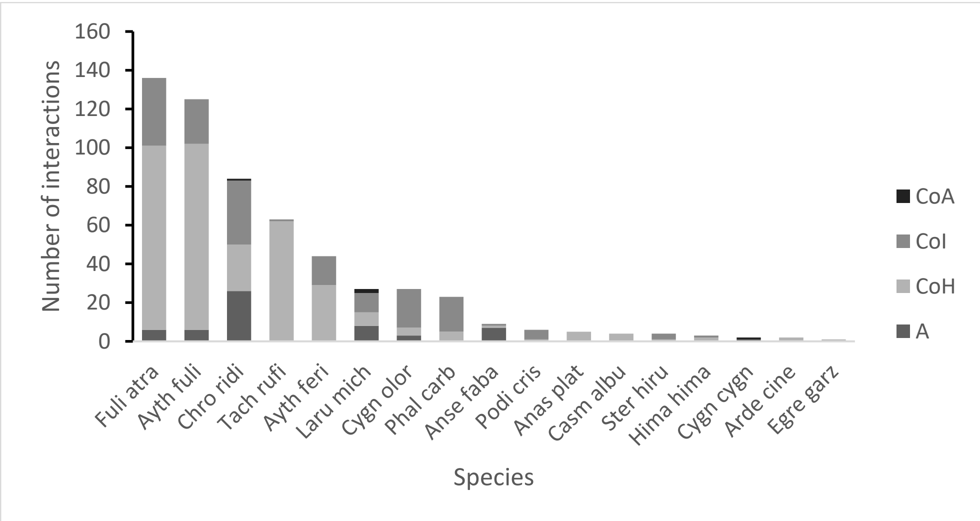

Figure 6. Total number of interspecific interactions and proportion of each interaction type per bird species observed during the passage, overwintering, and reproduction period 2022-2023. (CoA – cooperation for aggression, CoG – cooperation for grooming, CoF – cooperation for feeding, A – aggression)

We analyzed the species' preferences during interactions and concluded that the Tufted Duck had significantly more interactions as an instigator than the Great Crested Grebe, the Common Moorhen, the Mallard, and the Grey Heron (Fig. 7). The Eurasian Coot had significantly more interactions as instigator than Common Moorhens, Great Egrets and Mallards. Black-headed Gulls had significantly more interactions as instigators than Moorhens and Great Egrets (Fig. 7). Tufted Ducks consume aquatic plants at the bottom of the basin, and they are excellent divers, but spend less time the longer they dive (Stephenson *et al.*, 1986). Moreover, they spend most of their time feeding (Sutherland, 2009), similar to coots. An important result of the present study is the finding of a link based on continuous cooperation between Coots and Tufted Ducks between December and April, different trophic niches representing a plausible explanation for this result. Analyzing the ecology of coots, it has been shown that they spend ¾ (about 70%) of their time feeding to cope with intensive metabolic processes (Baaziz and Samraoui, 2008; Benlaharche and Boulakhssaim, 2018), but also that they feed more often in disturbed environments (Hafner *et al.*, 2004). The feeding behavior of the species has been documented in numerous studies (Horsfall, 1981; Draulans and Vanherck, 1987; Irwin and O'Halloran, 1997; Alouche, 1988; Pelsy-Mozzimann, 1999; Tamiser and Dehorter, 1999), from which we can describe 3 types of feeding: on the surface, through short-term diving or "grazing" (when the coots consume plant material from the shore); in early and mid-winter they forage on the surface and from February they start grazing on shore grasses, which is more energy efficient (Cramp and Simmons, 1980), also in preparation for the mating season.

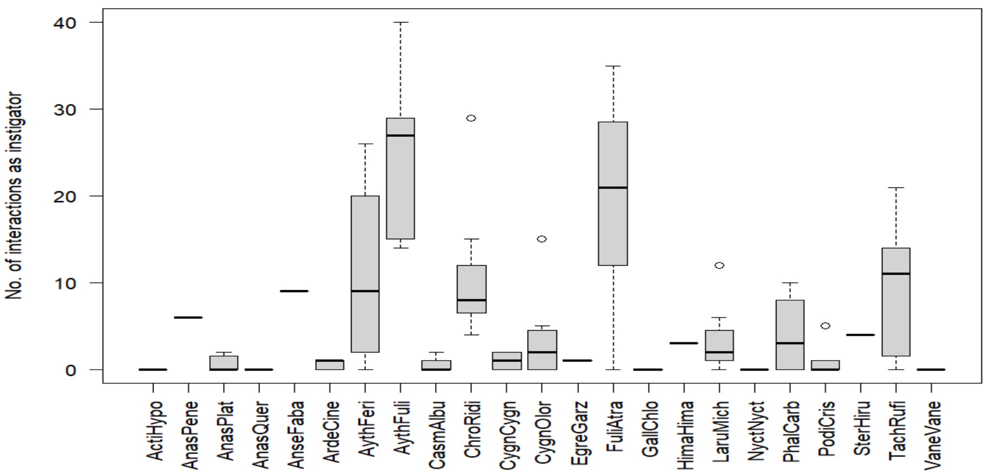

Figure 7. Number of interactions observed for each species in the role of instigator during eight months of observations. Boxplots represent the median (thick line inside the box), interquartile (box), minimum and maximum values (whiskers), and outliers (circles).

Thus, considering the time allocated to this behavior, but also the fact that coots are rarely aggressive during the winter period (Baaziz and Samraoui, 2008), it can be explained why it is the species that cooperates most often for food. Furthermore, their tendency to feed quantitatively more in autumn and less in winter (Paulus, 1988) has also been observed, intriguing in this context is the finding that coots tend to feed more so in environments where human influence is more intense (Hafner *et al.*, 2004).

In comparison to the rate of instigating behaviors manifested by the species, coots had significantly more interactions as reactors than Mallards, Grey Herons, Great Egrets, Moorhens, and Crested Grebes (Fig. 8). Coots had significantly more interactions as reactor than Great Crested Grebes, Common Moorhens, Great Egrets and Mallards. Black-headed Gulls had significantly more interactions as reactor than Mallards, Great Egrets and Common Moorhens (Fig. 8). Black-headed Gulls were present throughout the entire study period, the interspecific competition initiated by this species being based only on food, and after a period of feeding, their aggressiveness decreases significantly, so the seagulls do not have preferences for the places where they groom. Thus, a study that aimed to analyze the effects of the vegetation structure on Black-headed Gulls shows that the number of aggressions increases when the species is in an area with sparse and tall vegetation, with aggression occurring mainly in juveniles (Bukacińska and Bukaciński, 1993). Also, territory size has been shown to be influenced by interspecific interactions (Orians and Willson, 1964; Murray, 1971), so aggression could secure a territory in the case of interspecific competition (Reed, 1982). The most attacks initiated by this species were recorded in October, with the number of interactions decreasing every month. A possible explanation is abundant food, which can cause intense competition due to niche overlap with other species (Dhondt, 2012). Moreover, it is possible that individuals choose places densely populated with other bird species precisely to find food sources, preferring to tolerate other species at any other time of the day but when feeding. The connection between this behavior and the feeding of the species is explained by the dynamics of grooming behaviors during the 8 months, the frequency of joint grooming with other species decreasing along with the amount of food available on Crișul Repede.

The components of the interaction behavior: "instigation" and "reaction" were strongly and significantly correlated (Spearman Rank correlation: Rho = 0.937, $P < 0.001$), meaning overall that species showing more interactions interacted in both roles equally. Overall, some species (Tufted Duck, Black-headed Gull and Eurasian Coot) manifest significantly more interactions than others (Figs. 7 and 8).

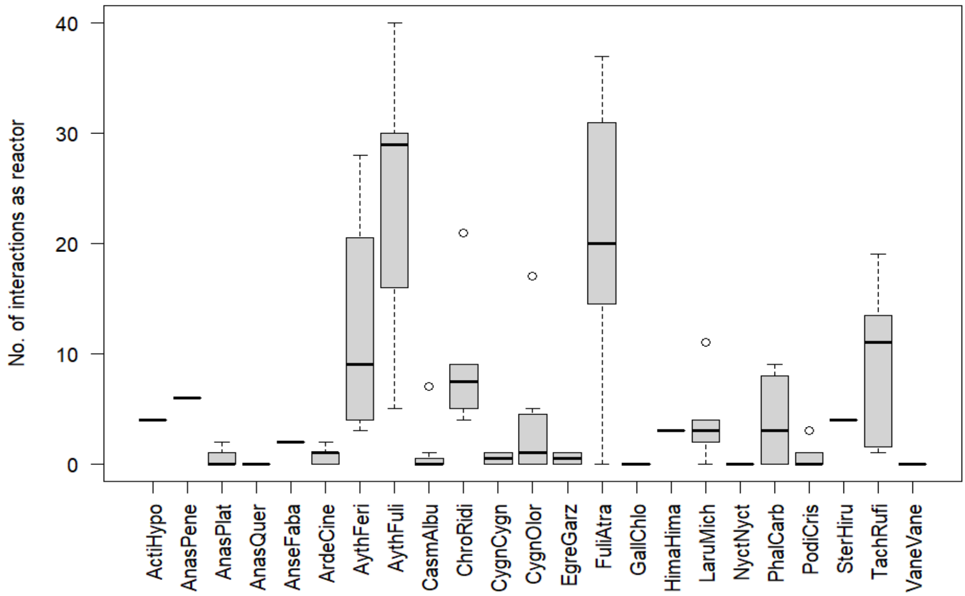

Figure 8. Number of interactions observed for each species in the role of reactor during eight months of observations. Boxplots represent the median (thick line inside the box), interquartile (box), minimum and maximum values (whiskers), and outliers (circles).

Considering all species and the whole observation period, the most frequent interaction observed was cooperation for feeding (CoF, 54.20% ± 37.51 SD), followed by cooperation for grooming (CoG, 30.07% ±30.74 SD), aggression (A, 12.28% ± 22.35 SD), and cooperation for aggression (CoA, 3.45% ± 12.13 SD). Tufted Ducks preferred to cooperate for feeding in 76.80% of the cases, while cooperation for grooming and aggression was observed in 18.40% and 4.80%, respectively. Black-headed Gulls was observed to perform a similar percentage of the interaction types CoG (39.32%,) A (30.95%,) and CoF (28.57). However, it also displayed cooperation for aggression (CoA, 1.19%) to a small extent. Eurasian Coots preferred to cooperate for feeding in 69.85% of the observed cases while also displaying cooperation for grooming (CoG, 25.74%) and aggression (A, 4.41%) to a smaller extent (Fig. 9).

We found a strong positive correlation between the number of individuals and the number of interactions in all species (Spearman’s rank correlation: Rho = 0.62, P < 0.001), meaning that the more individuals were present on the lake, the more interactions we found, and is also the first indicator that individual densities tend to rule over species preferences.

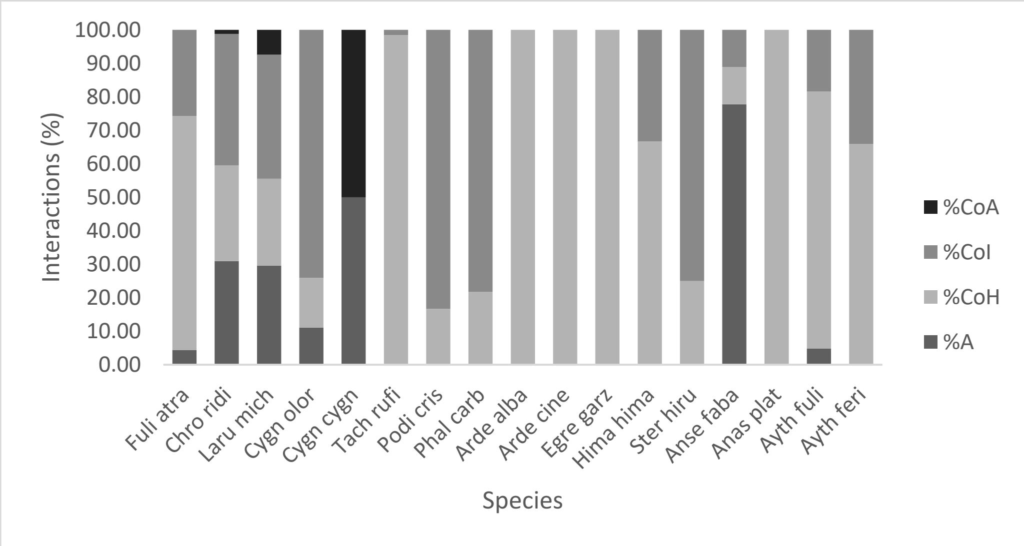

Figure 9. Barplot showing the percentage of interaction types performed by each species during the eight months of observations (CoA – cooperation for aggression, CoG – cooperation for grooming, CoF – cooperation for feeding, A – aggression).

For the three most interactive species (Eurasian Coot, Black-headed Gull, Tufted Duck), this relationship was also true with various correlation coefficients: Eurasian Coot– Spearman's rank correlation: Rho = 0.47, P = 0.002; Black-headed Gull – Spearman's rank correlation: Rho = 0.47, P = 0.002; Tufted Duck– Pearson's correlation: r = 0.36, P = 0.037.

We found no significant differences between months when all types of interactions were considered (Kruskal test: all P values > 0.05), which can be explained by the fact that abundant food in spring and summer does not generate interspecific competition, but the lack of food in winter should (DuBowy, 1988). However, since the temperatures during the winter of 2022 were abnormally high (up to 15^{0}C during the day), it is possible that more food sources, including smaller lakes that usually froze, became available to the species, leading to a similar quantity and quality of food throughout winter and spring/autumn. Moreover, we found no significant differences between months when just CoF was considered (Kruskal test: $\chi2$ = 10.50, df = 7, P = 0.162), which supports our hypothesis.

For the most interactive species, we found no significant differences between the proportions of all types of interactions with other species (ANOVA or Kruskal test P > 0.05 in all cases), indicating there is no preference for interacting with a particular species in one specific way.

Conclusions

After observing the water bird community in the Afonul Peța part of the Crișul Repede river for 8 months, the 23 species engaged in 3 out of the 4 types of interactions we have analyzed. The most interactive species were the Eurasian Coot, Black-headed Gull and Tufted Duck, with the most often encountered interaction type being the cooperation for feeding (CoF), closely followed by cooperations for grooming, defence interactions being the rarest of all. Tufted Ducks and Eurasian Coots are the two most common instigators for interactions, while Coots and Black-headed Gulls are the main reactor species. Surprisingly, interactions did not differ significantly throughout the months and seasons, and species generally did not interact with a preferred species more than with the others. For future research, we believe that more studies should focus on interspecific interactions in water birds, especially using data from several years of study in the current context of climate change and global warming. Moreover, it would be beneficial for future studies to look at the community as a whole rather than to observe two of the species in the area, since it might provide a more cohesive view on the context of the interactions taking place in the area.

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