Factors Affecting Colony Size and Breeding Parameters of Eared Grebe (Podiceps nigricollis) in Carp Ponds

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Factors Affecting Colony Size and Breeding Parameters of Eared Grebe (*Podiceps nigricollis*) in Carp Ponds

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Abstract.—Understanding important factors for breeding Eared Grebes (*Podiceps nigricollis*) is essential for its conservation. We aimed to study the impact of some factors on nests and breeding success in this species in fishponds (S Poland). Number of Eared Grebe nests were counted on particular carp ponds. Pond size, vegetation cover, number of nests in colonies of associated gull or tern species, and age of stocked common carp (*Cyprinus carpio*) were determined for all ponds with nests. We also investigated the relationship between nest size, material used to construct them and clutch size. Number of Eared Grebe nests positively correlated with number of breeding pairs of associated colonial species (terns or gulls). Selection of the breeding site by the Eared Grebe can be explained by appropriate nest protection by large colonies of associated species (Whiskered Tern *Chlidonias hybrida* and Black-headed Gull *Chroicocephalus ridibundus*). Nest size was not related to clutch size. A negative relationship between breeding success and number of nests of Eared Grebe was found. Food is a not limiting factor for the Eared Grebe on fishponds with extensive production, and presumably other factors such as weather conditions may explain the low breeding success of this species. *Received 14 May 2021, accepted 21 Jul 2022.*

Key words.— associated species; breeding success; carp age; clutch size; habitat requirements

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The selection of a safe nesting site is an important determinant of reproductive success in birds (Mainwaring *et al.* 2014). Birds choose the safest sites possible for nesting and chick rearing to reduce the risk of predation (Newton 2013, Mainwaring *et al.* 2014). Birds protect their nests against predators in various ways. They can hide their nests in dense vegetation, thereby increasing brood survival. Another defensive adaptation is creating breeding colonies or nesting in colonies with other, more aggressive species (Newton 2013). Colonially nesting birds have more effective mobbing defenses against predators (Caro 2005). The reduction of predation risk through direct defense by colonial birds has been suggested to be a significant benefit of groups (Krause and Ruxton 2002). Predation of Pochard (*Aythya ferina*) and Tufted Duck (*Aythya fuligula*) nests was found to be lower within than outside Black-headed Gull (*Chroicocephalus ridibundus*) colonies (Väänänen 2000).

One species often associated with colonies of gulls (*Larus* spp.) and marsh terns (*Chlidonias* spp.) is the Eared Grebe (*Podiceps nigricollis*; Cramp and Simmons 1977). It inhabits freshwater marshes and lakes, often with extensive shallows with dispersed, submerged vegetation and scattered patches of reeds (O'Donnel and Fjeldså 1997). This colonial breeding bird species occupies reedbeds or in places with waterweeds on the surface (O'Donnel and Fjeldså 1997). Breeding sites of this species on a local scale are unstable, and birds often abandon them after one or a few years. Quality and quantity of submergent plants may affect nest success, since some nest materials form a firmer nest (Boe 1993). Nests built of harder leaves and stalks are stronger and do not disintegrate easily under the influence of waves.

Food availability is very important for reproduction (Ruffino *et al.* 2014). For example, the reproductive performance of gulls is dependent on food resource availability (Pierotti and Annett 1990, Bukaciński *et al.* 1998, Gwiazda *et al.* 2015). The Eared Grebe feeds less on fish and more on insects and mollusks (Cramp and Simmons 1977). Ponds occupied by different common carp (*Cyprinus carpio*) cohorts can offer different food resources for piscivorous birds. Kloskowski *et al.* (2010) and Kloskowski (2011) showed that fish availability may significantly affect habitat use by smaller grebes. One year old common carp are small in size and can be food for birds, but older carp (2 or 3 years old) are competitors because they are too big to be consumed and forage on invertebrates at the bottom of the pond, reducing food for some birds. Kloskowski *et al.* (2010) suggested that the density of smaller grebes was negatively associated with the fish age/size gradient.

The breeding biology of the Eared Grebe has not been sufficiently studied (Cramp and Simmons 1977, Fjeldså 2004, Delahoussaye and Conover 2020). The breeding success of this species in Europe is not known (Cramp and Simmons 1977, Cullen *et al.* 2020). It is not known if breeding success is affected by associated species in the colony or food resources. The aim of this study was to quantify the factors affecting the number of nests, clutch size, and breeding success of the Eared Grebe in carp ponds. Additionally, the size of nests of this species was studied. We hypothesized that habitat safety (pond size, vegetation cover, colonies of associated species) would influence the number of nests and breeding success of the Eared Grebe. Furthermore, we hypothesized that prey availability, which we predicted would be greater in ponds with carp fry and lesser in ponds with older carps, would impact the number of nests and breeding success.

Methods

Study area

This study was carried out at five carp pond complexes in the Upper Vistula River Valley (southern Poland): Spytkowice (50°01′N, 19°29′E; 480 ha), Bugaj (49°59′N, 19°26′E; 180 ha), Rudze (49°58′N,19°26′E; 120 ha), Przeręb (50°02′N, 19°25′E; 410 ha), and Stawy Monowskie (50°02′N, 19°21′E; 210 ha) contained 95 ponds (Fig. 1). Each complex contained 11–24 ponds, whose areas varied from 1 to 45 ha (10 ha on average). The mean water depth of all sites was 1.2–1.5 m. The emergent vegetation formed 3–6 m wide belts of reeds around perimeter of ponds, and many ponds were covered with plants with floating leaves: yellow floating heart (*Nymphoides peltata*) and water chestnut (*Trapa natans*). In addition, there were islands of various sizes in some ponds, on which shrubs or trees grew. All sites were surrounded by agricultural land or settlements.

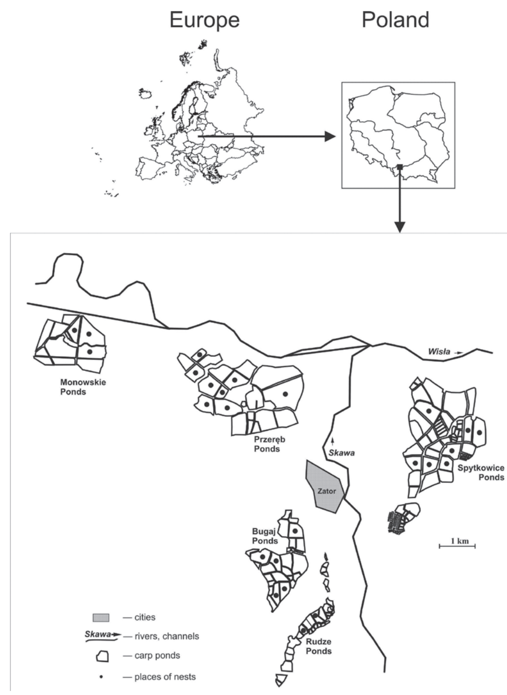

Fig. 1. Distribution of fishponds with Eared Grebe nests. Inset shows location of study area in southern Poland.

The common carp was the main fish species reared in the ponds. Similar production rates and fish densities were recorded at the studied sites according to data from fish farm owners. Average gross yields were given as c. 300–400 kg/ha. Owing to their high species richness and abundance, the ponds in this study area are of great importance to waterbirds (Dobrowolski 1995, Ledwoń *et al.* 2014) and are designated as an Important Bird Area (Wilk *et al.* 2010).

Study Species

Eared Grebes occur in Europe, Middle East, southeast Asia (*P. n. nigricollis*), southern Africa (*P. n. gurneyi*) and North America (*P. n. californicus*). According to IUCN this species is classified as "Least Concern". In Poland, they occur unevenly mainly in the low and partially upland part of the country (Tomiałojć and Stawarczyk 2003). The breeding population of Eared Grebe in Poland decreased from 4–5 thousand pairs to 1–2 thousand pairs during last 20 years (Chodkiewicz *et al.* 2019). Eared Grebe was included in the Red List of Polish Birds with category "Vulnerable" (Wilk *et al.* 2020).

Field study

Eared Grebes were studied during the breeding season (May–July) from 2014 to 2019. In total, 468 nests were located on 25 ponds. Eight ponds were occupied as breeding site for two years. Each pond was visited once every two weeks to locate breeding birds and nests.

Nests were counted on each pond from the shore using binoculars (10x42) and a spotting scope (20-60x82). Occupied nests were categorized as early clutch (start of incubation in May) or late clutch (start of incubation in June). Moreover, the numbers of breeding pairs of associated colonial birds (Black-headed Gull or Whiskered Tern [*Chlidonias hybrida*]) were counted. The following factors were collected for all ponds with nests: pond size, vegetation cover of pond area by floating plant species (category: 0–25%, 26–50%, > 51%), number of nests in colonies of associated gulls or terns, age of stocked common carp (category: 1, 2, or 3 years old). Pond size was calculated using ArcGIS software (ESRI 2019). Information about the age of common carp in each pond was obtained from fish farmers.

Nests measurements were carried out from the water using inflatable boats. The diameters of above-water part of 103 nests were measured using a ruler with an accuracy of 1 cm. The plant species used to construct each nest were determined. The number of eggs in nests was determined for 169 nests throughout the study period. During field studies in each breeding colony, we collected data in time with a maximum of 30 min to reduce bird stress. Breeding success was determined as maximum number of young independent of their parents (> 20 days old) per nest observed in the studied ponds in July.

Statistics

To determine if the number of nests and of breeding successes were normally distributed, Kolmogorov-Smirnov tests were used. Results showed that number of nests was not normally distributed (χ^2 = 6.985; df = 2; P = 0.03) but that breeding success was normally distributed (χ^2 = 2.543; df = 1; P = 0.11).

A generalized linear mixed model (GLMM) was used to estimate the number of Eared Grebe nests (Poisson distribution, logit link function) and the breeding success (normal distribution, log link function). Predictor variables were pond size (AREA), share of vegetation cover (COVER), number of breeding pairs of associated colonial birds (COLONY), period of egg incubation (TERM), and age of reared common carp (FISH). Number of breeding pairs of Eared Grebes (GREBES) was included as a predictor variable in the model for breeding success. The random factors were the year and pond. Number of nests was different in the study years and on particular ponds due pond management and weather conditions. Ponds without Eared Grebe nests were not included in analysis because this species requires an excess of places suitable for breeding (Cullen et al. 2020) and this study does not focus on habitat choice. Principal Component Analysis was used to check collinearity among the environmental variables (Freckleton 2011).

Differences in nest size of the Eared Grebe depending on the plant species from which they were built were studied using ANOVA and post-hoc Tukey test. Correlation between number of eggs and size of nests was analyzed by Pearson correlation. The data were analyzed with SPSS software (ver. 24.0; IBM Corp. 2016).

RESULTS

The number of Eared Grebe nests positively depended on number of breeding pairs of colonial associated bird species (Table 1, Fig. 2). Other factors (pond size, share of vegetation cover and period of egg incubation, age of carp) were not important.

Eared Grebe nests were built using leaves and stalks of the water chestnut, common bulrush (*Typha latifolia*), common reed (*Phragmites australis*), and yellow floating heart. The average diameter of above-water part of Eared Grebe nests was 28.2 cm (SD = 5.28, range: 17–45 cm, n = 125). The size of nests was not depended on the material used for its construction (F = 1.736, df = 3, P = 0.16; Fig. 3). The average clutch size of the Eared Grebe was 2.7 eggs per nest (range: 1–4, n = 103). The size of Eared Grebe nests was not related to the number of laid eggs (r = 0.068, n = 138, P = 0.49).

We did not find young of Eared Grebe in 18% of the studied colonies (6 of 33). Average breeding success in successful colonies was 1.4 young per nest (SD = 1.09, range: 0.1–3.5,

Table 1. Summary of generalized linear mixed model describing components of the number of occupied nests by the Eared Grebe. Significant differences are marked in bold. Explanation of factors: AREA: pond size, COVER: share of vegetation cover, COLONY: number of breeding pairs of associated colonial birds, TERM: period of egg incubation, and FISH: age of reared common carp.

Factor	Estimates	Standard errors	F	*P*	*n*
Intercept	685.86	169.72	2.263	0.07	33
AREA	-0.012	0.018	0.451	0.51	33
COVER	0.291	0.500	0.170	0.84	33
TERM	-0.364	0424	0.737	0.40	33
COLONY	**0.010**	**0.002**	**14.754**	**0.001**	**33**
FISH	-0.225	0.480	0.121	0.89	33

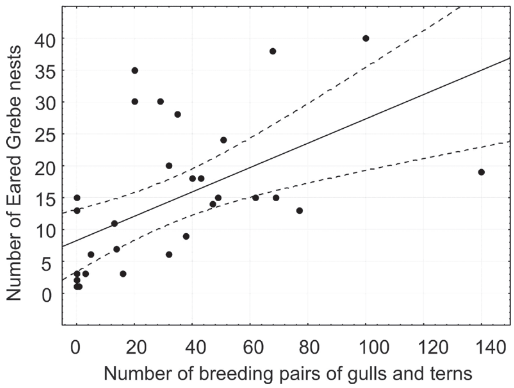

Fig. 2. Relationship of Eared Grebe nests and number of breeding pairs of associated colonial bird species in the studied ponds. Regression (solid line) and 95% confidence intervals (dotted line) were given.

n = 27). GLMM showed that breeding success of Eared Grebe negatively depended on number of breeding pairs (Table 2, Fig. 4).

Discussion

The Eared Grebe typically breeds on small, shallow, and plentifully vegetated waters. Many carp pond complexes represent a semi-natural ecosystem which is a valuable habitat for the Eared Grebe population (Wilk *et al.* 2010). Habitats of carp ponds can change between years due to degree of filling of water, periodic desludging, and mowing of coastal vegetation (Wiehle 2020). These management strategies can explain irregular nesting of the Eared Grebe on carp ponds. We did not find that number of Eared Grebe nests depended on pond size. Similarly, vegetation cover was not an important factor for number of Eared Grebe nests. However, in Great Salt Lake (Utah, USA) higher percent cover of submerged aquatic vegetation was found to be an important factor for nesting Eared Grebe (Delahoussaye and Conover 2020). This difference may be due to the fact that in our study, we included only the sites where breeding was recorded. Ponds with a small number of plants without Eared Grebe nests were not analyzed.

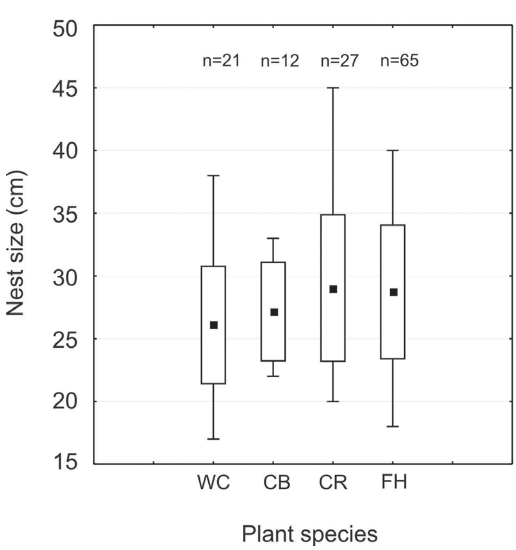

Fig. 3. Mean (SD and range) of diameter of above-water part of Eared Grebe nests constructed depending on the plant species used to build nests. Description: WC: water chestnut, CB: common bulrush, CR: common reed, and FH: yellow floating heart.

Our study showed that the number of Eared Grebe nests was correlated only with the number of breeding birds of associated species in the colony. The parents of Eared Grebe defend eggs and chicks against predators (Cramp and Simmons 1977). However, a greater size of gull and tern colonies can give better protection to the clutch and nestlings by group defense against predators. Moreover, gulls and terns will attack a potential predator while it is still outside the colony, giving the Eared Grebes time to quickly cover the eggs with plant material and leave the nest. Marsh Harriers (*Circus aeruginosus*) are egg-robbing predators on the studied ponds. Eared Grebe often begin breeding after the growth of plants with floating leaves and the initiation of breeding colonies of gulls or terns on the studied ponds.

An important factor influencing the size of Eared Grebe colonies could be the fish community. Kloskowski (2011) showed that fish size structure may be an important cue for the breeding habitat choice of the Red-necked Grebe (*Podiceps grisegena*). Food for this grebe consists of invertebrates and less fish, similar to the diet of the Eared Grebe. However, we did not find that the number of Eared Grebe nests was greater in ponds with fish fry than in ponds with fish of greater

Table. 2. Summary of generalized linear mixed model describing components of the breeding success per nest of the Eared Grebe. Explanation of factors: GREBES: number of pairs of breeding Eared Grebes, AREA: pond size, COVER: share of vegetation cover, COLONY: number of breeding pairs of associated colonial birds, TERM: period of egg incubation, and FISH: age of reared common carp.

Factor	Estimates	Standard errors	F	*P*	*n*
Intercept	0.357	1.110	0.117	0.67	33
GREBES	**-0.002**	**0.003**	**6.492**	**0.02**	**33**
AREA	0.003	0.025	0.017	0.90	33
COVER	-0.422	0.489	0.379	0.70	33
TERM	0.231	0.440	0.276	0.61	33
COLONY	0.001	0.003	0.183	0.68	33
FISH	0.498	0.526	0.463	0.64	33

size. The explanation for this may be that all ponds provide an adequate food base. There are also other fish species in the studied ponds, and density of macroinvertebrates can be great due to small carp stocks there.

The size of nests located on ponds was not depended on the plant material. However, Boe (1993) showed that quality of submergent plants may affect nest success since some nest materials form a firmer nest. Bocheński (1961) showed greater mean clutches of Black-necked Grebe (3.2 eggs) than we found (2.7 eggs). We did not find a relationship between the diameter of above-water part of nests and number of eggs. However, Bocheński (1961) suggested that the inner diameter of the nest of an Eared Grebe was influenced by the number of eggs laid in the nest. Further research in other regions is required to confirm these results.

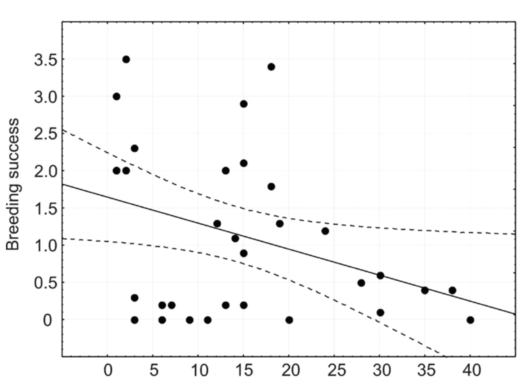

Fig. 4. Relationship of breeding success and number of breeding pairs of Eared Grebe in the studied ponds. Regression (solid line) and 95% confidence intervals (dotted line) were given.

We did not find young in 6 of 33 studied ponds with colonies of Eared Grebe with 3–40 nests. It is difficult to explain this situation. Major causes of loss of eggs and chicks in this species were wave action in high winds and predators (Broekhuysen and Frost 1968, Cramp and Simmons 1977, Boe 1994). The most likely cause of nest abandonment was weather condition because we found flooded nests with eggs.

Breeding success of Eared Grebe was variable (Cullen *et al.* 2020). According to Hordowski (2017) number of young produced in year is 1.1–2.0 per pair, similar to our study. Mean number of young (> 2 weeks), per nest was 1.09 in 1985 and 0.53 in 1986 in SW Canada (Breault 1990). Cullen (1998) showed mean number of young to survive to 15 days post-hatch was 1.02 per nest in 1995 and 0.87 per nest in 1996. We did not find an influence of colonies of associated species on the breeding success of Eared Grebe. Conversely, Ashoori *et al.* (2020) showed that chicks of Great Crested Grebes (*Podiceps cristatus*) had higher survival rates up to at least 20 days old in mixed colonies with Whiskered Terns than in monospecific colonies on the southwest coast of the Caspian Sea. Anti-predatory activity of Whiskered Terns gave better protection for chicks. We found a negative relationship between number of young and number of nests for Eared Grebe. Breault (1990) did not find a trend between colony size and hatching success or chick survival. Lower number of young per nest in larger colonies could be explained by greater competition between birds. Szostek *et al.* (2013) showed that reproductive success of the Common Tern (*Sterna hirundo*) was not related to nest density but to overall colony size, possibly a result of resource depletion and food competition. Food is not a limiting factor for the Eared Grebe on fishponds, but interspecies interactions are possible (disturbance or robbing material from the nest by marsh terns). However, Wiehle (2020) showed that breeding success of the Eared Grebe was very low in southern Poland despite colonial nesting (a maximum density c. 40 pairs/ha), when competition with the Whiskered Tern was low. Fiala (1991) showed that parents of Eared Grebe may not be able to feed more than two chicks. More chicks early in the feeding period provide a secured success in case the older chicks die. It is probable that other factors such as weather conditions (heavy rainfall and strong winds) may explain the low breeding success of the Eared Grebe due to greater mortality of chicks.

Well-managed carp ponds provide good environmental conditions for the Eared Grebe. We concluded that Eared Grebe have greater number of nests in habitats with better protection (presence of larger colonies of associated bird species). Larger colonies of associated bird species can be important for survival of nests. On the other hand, lower breeding success of the Eared Grebe at higher densities may result from unknown factors such as weather conditions. Carp production in ponds should take into account the requirements of bird species, especially when numbers are decreasing. Management of carp ponds, which ensures the high stability of the habitat conditions, is recommended for the protection of Eared Grebe.

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