

Local ecological knowledge and attitude toward the Great Cormorant (*Phalacrocorax carbo*) among the fishermen's community at Beni Haroun Dam, Algeria

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Abstract

Incorporating the perspectives of local fishing communities and their ecological knowledge (LEK) can enhance policymaking and improve wildlife and economic management strategies. This study aimed to evaluate the local ecological knowledge of fishermen at Beni Haroun Dam regarding the Great Cormorant (*Phalacrocorax carbo*) a species legally protected under Algerian law, and to reveal their conservation attitudes toward this species. We qualitatively evaluated and analyzed the respondents' local ecological knowledge, while their attitudes were quantitatively assessed by correlation with factors from the sociological and fishing profiles. Fishermen successfully identified the ecological properties of cormorants, including their habitats, prey types, and foraging behavior. They demonstrated a generally favorable attitude towards the conservation of Great Cormorants. Fishermen's reports were compared against published data on a topic-by-topic basis, showing a moderate to relatively high level of ecological knowledge overall, alongside some notable overestimations (e.g., in daily food intake and residency duration). No significant connections were identified between fishermen's attitudes and any socio-demographic or fishing-related variables. We therefore reiterate the significance of the current study as foundational knowledge about *P. carbo* in Beni Haroun Dam and the incorporation of Local Ecological Knowledge into conservation strategies and future ecological studies for Mediterranean inland freshwater habitats.

Key words: local ecological knowledge; human-wildlife conflict; Beni Haroun Dam; *Phalacrocorax carbo*; ethno-ornithology; Mediterranean wetlands.

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INTRODUCTION

The Great Cormorant (*Phalacrocorax carbo*) is one of the most important piscivorous predators in aquatic environments (Lyach *et al.*, 2018). It preys on numerous fish species of differing sizes (Källo *et al.*, 2023), with its high mobility and opportunistic feeding behavior enhancing its influence across freshwater, estuarine, and coastal ecosystems (Dinesen *et al.*, 2024). These traits, along with its tendency to hunt in large groups, make it both an ecological concern and an economic burden.

In recent years, cormorant populations in Europe have significantly increased, primarily due to strong conservation initiatives and legal protections implemented by legislators (Harding and Mesler, 2022). The success of these conservation efforts intensified tensions between the species and fishing communities (Saarikoski *et al.*, 2024), since numerous fishermen claim financial losses due to predation and disturbances produced by Great Cormorants (Zumpano *et al.*, 2024). While present regulations typically permit

lethal control, set hunting seasons, and adopt protective measures (Pimenta *et al.*, 2024), stakeholders regularly doubt their efficacy, citing persistent population expansion and inherent constraints (Carss, 2022).

The continental subspecies *Phalacrocorax carbo sinensis* has significantly contributed to this range expansion, establishing new wintering and feeding habitats throughout Europe and neighboring areas (Carss *et al.*, 2009; Lyach *et al.*, 2018). Its habitat selection is determined by food availability, lesser hunting pressure, and moderate winter weather, allowing it to establish itself in previously vacant areas (Collas and Burgun, 2011). In Algeria, the Great Cormorant is legally protected under Executive Decree No. 12-235 of 3 Rajab 1433 corresponding to 24 May 2012, setting the list of protected non-domesticated animal species (République Algérienne, 2012), which prohibits its hunting, capture, and destruction nationwide.

Algeria serves as a significant waypoint on the Mediterranean migratory route for Western Palearctic waterbirds, acting as both a wintering habitat and a transit location between European breeding

regions and African wintering sites (Samraoui *et al.*, 2011; Bensaci *et al.*, 2013; Bouldjedri and Mayache, 2020). Every winter, the nation receives as many as 97 species of waterbirds, including eight piscivorous species, such as the Great Cormorant (Samraoui *et al.*, 2011). During this phase, the species inhabits a range of water habitats to suit its feeding requirements, with large dams and reservoirs constituting its principal foraging and roosting sites (Benmetir *et al.*, 2020; Belfethi and Moulai, 2022).

These water bodies are significant to Algeria's inland fishing sector. Freshwater fisheries are concentrated in dams and reservoirs across northern Algeria (Tandjir, 2008), contributing to the national fish production, supplementing marine fisheries and supporting local fishing communities (Ferroukhi *et al.*, 2022). The spatial overlap between cormorant foraging areas and active fishing zones has proved to create human–wildlife conflict (Vieite *et al.*, 2022; Villar *et al.*, 2024), yet this issue remains relatively understudied in the Algerian context.

Despite the observed increase in cormorant populations across Algerian freshwater systems in recent decades (Benmetir *et al.*, 2020), to our knowledge, no published study has explored local ecological knowledge among fishermen or assessed their attitudes toward the species' impacts on fishing activities. This study was conducted at Beni Haroun Dam, which accommodates more than 6,000 Great Cormorants (DGF, 2018), making it a key site for understanding human–cormorant interactions in North Africa. This study there-

fore pursues two specific aims: (1) to document and evaluate the accuracy of fishermen's local ecological knowledge (LEK) of the Great Cormorant relative to the published scientific literature, and (2) to assess fishermen's attitudes toward the conservation of the species and identify the socio-demographic and fishing-related factors associated with these attitudes. The findings contribute to human wildlife conflict research, enable the incorporation of local ecological knowledge into conservation frameworks, and provide baseline data to inform the development of management strategies for inland aquatic systems in North Africa.

METHODS

Study area

Beni Haroun Dam, the largest hydraulic structure in Algeria, is situated in northeastern Mila Province ($36^{\circ}33'18.55''$ N; $6^{\circ}16'10.93''$ E) among the eastern Tellian Atlas Mountains (Fig. 1). The area features sedimentary rock formations, including limestone, marl, and sandstone, and has a Mediterranean climate characterized by hot, dry summers and warm, wet winters (500–800 mm annual precipitation). The geography ranges from northern highlands to middle valleys and southern plains, diverting surface water toward the Rhumel and Endja rivers (Chebbah and Kabouret *et al.*, 2023; Bouchareb *et al.*, 2025; Marouf and Remini, 2019).

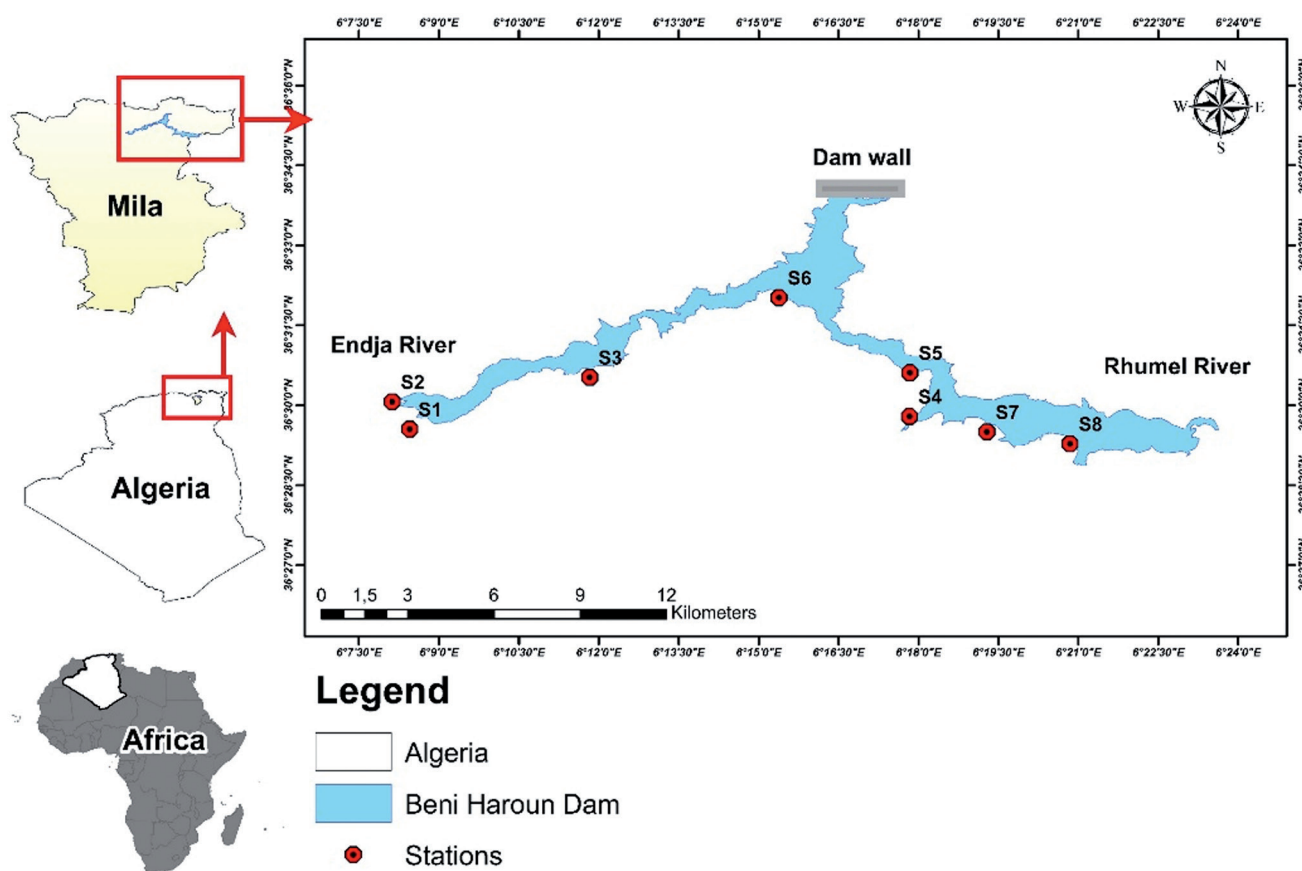


Fig. 1. Geographical location of the Béni Haroun Dam.

Built on the Oued El Kebir river downstream of where the Rhumel and Endja meet, the dam is a gravity structure in roller-compacted concrete (RCC), 710 m long at the crest and 118 m high above its foundation, operating since 2002, with a total storage capacity of roughly one billion cubic meters ($1 \times 10^9 \text{ m}^3$) and a useful volume of 732 hm^3 between elevations of 172 and 200 m; it currently holds around 435 million cubic meters, spread over a reservoir surface of about 39.29 km^2 ($\approx 4,000 \text{ ha}$), with an average depth of 24 m (Kabour and Chebbah, 2023; Rebbah *et al.*, 2025). Water transparency, assessed through turbidity measurements at 20 stations across the reservoir, ranged from 3.38 to 101 NTU (mean 16.5 NTU), with the highest values recorded in the Oued Endja arm, likely reflecting sediment input and agricultural runoff, and the lowest on the Oued Rhumel side and surface temperature ranged from 13.9 to 25.5°C (Rebbah *et al.*, 2025). Turbidity rather than Secchi disk depth is reported here, as the latter becomes unreliable for differentiating water quality once turbidity exceeds roughly 20–40 NTU in productive reservoirs (Golubkov and Golubkov, 2024). The shores and surrounding areas of the reservoir are characterized by a mosaic of cereal fields, olive groves, and woody vegetation dominated by *Pinus halepensis*, *Cupressus sempervirens*, *Eucalyptus camaldulensis*, *Tamarix africana*, and *Populus alba*, together with stands of *Phragmites australis*. These habitats provide suitable resting and roosting sites for wintering waterbirds, particularly the Great Cormorant (*Phalacrocorax carbo*). It provides water supply for six provinces, irrigates approximately 41,000 acres, and sustains local fisheries and socio-economic activities (ANBT, 2014; Marouf and Remini, 2019). The dam also supports recreational and commercial fisheries, having benefited from fish stocking three times in the past 10 years, and acts as a destination for ecotourism, underscoring its essential environmental and economic importance (Habila, 2017; DSPAM, 2025). Among the avifauna using the reservoir, the Great Cormorant (*Phalacrocorax carbo*) is the dominant wintering species, accounting for 37.82% of the relative abundance of all birds recorded at the dam (Chabou *et al.*, 2020). According to the *Direction Générale des Forêts*, 3,675 wintering Great Cormorants were counted at Beni Haroun Dam in 2013, representing 70% of the total population recorded in Algeria that year, while a subsequent count in 2018 recorded 6,947 individuals at the dam (DGF, 2013; 2018).

Data collection and sampling procedure

Face-to-face semi-structured interviews were conducted between February and April 2025, with fieldwork taking place in eight fishing sites along the Beni Haroun Dam, which are considered the most important fishing sites frequented by fishermen regularly, distributed from west to east as follows: S1 (El Maleh 1), S2 (El Maleh 2), S3 (Djelama), S4 (El Medyous), S5 (Ferdoua), S6 (Sidi Merouane), S7 (Kikaya 1), and S8 (Kikaya 2) (Fig. 1). Interviews were conducted with fishermen who were available and willing to participate (Villar *et al.*, 2024). They were approached individually to prevent interference from other fishermen, which can introduce biases (Vieite *et al.*, 2022). The average time to complete the survey was estimated at 30 min (Liordos *et al.*, 2025).

The questionnaire consisted of three sections (Supplementary Material). The first section was devoted to the fishermen's profile and included questions about their socio-demographic characteristics (age, location and duration of residence, education, number of children, income, and internet access) and fishing activity (whether they still fish, fishing experience, fishing time, fishing effort, fishing

locations, fishing gear, and target species). The second section was devoted to fishermen's knowledge of the Great Cormorant, where we asked several questions about the target species' habitat, such as period of residence and preferred location (Vieite *et al.*, 2022), and the third section was devoted to fishermen's attitudes toward its conservation. We also showed the fishermen an illustrative image of a Great Cormorant to assess whether they were able to identify it. Following an emic-etic approach (Cheung *et al.*, 2011), fishermen's responses regarding cormorant ecology were compared with scientific literature to assess the accuracy of their ecological knowledge. In order to assess whether local knowledge aligns with, deviates from, or enhances scientific understanding of cormorant ecology, migration patterns, and habitat utilization, this dual perspective enables the merging of culturally-specific observations with known ecological data.

Statistical analysis

Attitude data were analyzed using R version 4.4.3 (R Core Team, 2025). A three-point Likert scale (unfavorable, moderate, favorable) was transformed to continuous scores ranging from 0 to 1 (0.5 for moderate replies) (Braga and Schiavetti, 2013; Braga *et al.*, 2018). Negatively worded questions (Q1–Q4) were reverse-coded so that higher scores indicated more positive attitudes across the seven questions. Individual mean attitude index was determined (range: 0–1) and divided into three categories: negative (0–0.33), moderate (0.34–0.66), and positive (0.67–1.00) (Vieite *et al.*, 2022). Scale reliability was examined using Cronbach's alpha (Cronbach, 1951), and we used the Shapiro-Wilk test to check normality. Fishing effort was extracted from how many days per week each fisherman spends fishing and also grouped into three classes: low (1–2 days/week), moderate (3–4 days/week), and high (5–7 days/week) (Vieite *et al.*, 2022). The prevalence of attitude groups was compared using a chi-square goodness-of-fit test.

We examined predictors of attitude scores using Spearman's rank correlation coefficient to test relationships between the mean attitude index and continuous variables (age, years of experience, hours per session, and number of children). To analyze differences between the mean attitude index and categorical variables, we performed the appropriate non-parametric test, depending on the number of independent groups. For multi-level factors (residence, education, and fishing effort), we used Kruskal-Wallis H tests with Dunn's post-hoc tests (Bonferroni-corrected). For binary factors (internet access, fishing for consumption, and fishing purpose), we used Mann-Whitney U tests. Statistical significance was set at $\alpha = 0.05$. Additional packages used included car, psych, and ggplot2 (Wickham, 2016; Fox and Weisberg, 2018; Revelle, 2023).

RESULTS

Socio-demographic profile of surveyed fishermen

This study was conducted through interviews with 88 fishermen frequenting eight different sites around Beni Haroun Dam, over a period of three months. Due to local traditions, all interviewees were male and over the age of 29. Among them, 80 practiced recreational fishing, while only eight were commercial fishermen. The average age of fishermen was 53 years. Nevertheless, there was a difference between the two main groups: the average age of commercial fishermen was lower (47 years) than that of recreational fishermen (53 years), with the maximum age reaching 97 years.

Regarding educational level, basic education (intermediate education) was predominant among the interviewees ($n=32$; 36.4%),

with no university-level attainment among commercial fishermen, while this level was observed only among recreational fishermen ($n=10$; 12.5%). As for internet use, the majority of fishermen interviewed ($n=65$; 73.9%) reported using it in their daily lives, with a higher rate among commercial fishermen ($n=7$; 87.5%) compared to recreational fishermen ($n=58$; 72.5%).

With respect to income from fishing, this was reported exclusively by commercial fishermen, while all recreational fishermen affirmed that they engaged in fishing for non-material reasons. However, most recreational fishermen ($n=52$; 65%) stated that they occasionally consumed the fish they caught if the size was sufficient. For commercial fishermen, the declared monthly income ranged between 10,000 and 150,000 Algerian dinars (approximately 75–1,125 USD).

According to the collected data, the majority of interviewees are still practicing fishing ($n=80$; 90.9%). Their experience in this field ranged from 1 to 55 years, with an overall average of 24.4 years. The commercial group presented a lower average experience of 24.1 years, with experience ranging from 6 to 38 years, while the recreational group had an average of 24.5 years, with a broader range (1–55 years).

Concerning the frequency of fishing during the week, fishing was practiced from one to seven days per week. The results showed that the commercial group has a higher average frequency (4.25 days per week), while the recreational group displayed less frequent fishing (an average of 3.01 days per week).

Species recognition and vernacular names for the Great Cormorant

When shown the images, most fishermen were able to recognize the target species ($n=86$; 97.7%). Of these, 54 fishermen offered a

name for it. The name “Al-ghaq” was the most commonly used by fishermen to refer to the Great Cormorant ($n=15$; 27.8%), followed by “Al-brak” ($n=13$; 24.1%), then “Ghorab al-ma” ($n=8$; 14.8%), followed by “Al-ghattas” ($n=5$; 9.3%), and then “Al-ghora” and “Al-marzouk” ($n=3$; 5.6% each), as well as “Tair al-assouad,” and “Sardana” ($n=2$; 3.7% each), and “Tiar al-ma” ($n=1$; 1.9%). Analysis by group showed that the name “Ghorab al-ma” was most frequently cited within the commercial group ($n=2$; 25%), while the name “Al-ghaq” was most commonly used among members of the recreational group ($n=14$; 17.5%).

Perceived population trends and seasonality of the Great Cormorant

The data showed that 53 fishermen (60.2%) reported an increase in the number of Great Cormorants in recent years, while 3 fishermen (3.4%) recorded a decrease, and 14 fishermen (15.9%) noted stability, whereas 18 fishermen (20.5%) observed no change. When analyzing the recreational fishermen, 46 fishermen (57.5%) reported an increase in cormorant numbers, compared to 3 fishermen (3.8%) reporting a decrease, 13 fishermen (16.2%) reporting stability, and 18 fishermen (22.5%) reporting no change. As for the commercial fishermen, 7 fishermen (87.5%) reported an increase in cormorant numbers, none reporting a decrease or lack of observation, while one fisherman (12.5%) reported relative stability.

Regarding the temporal distribution of the Great Cormorant, fishermen’s reports indicate that this species is observed at Beni Haroun Dam from late September to early June (Fig. 2), with an increase in sightings during the winter months, particularly in January and February ($n=84$; 95.4%). With respect to the residency period of the Great Cormorant at the dam, fishermen’s estimates varied and were

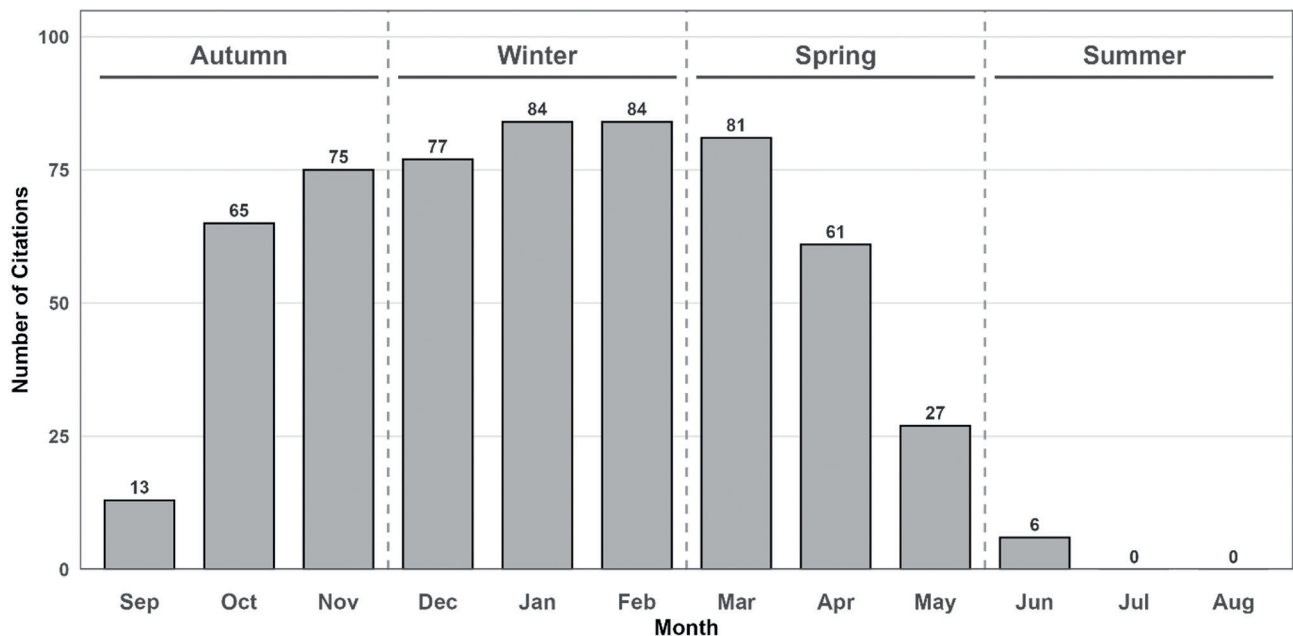


Fig. 2. Bar plot demonstrating the total number of citations regarding Great Cormorant presence during a whole annual cycle, organized from September to August. The x-axis depicts individual months, while the y-axis denotes the frequency of citations. The image indicates a surge in reported observations during the winter and early spring months, with citations dropping drastically over the spring and summer periods.

categorized into several timeframes (Fig. 3). Category A, which included 28 fishermen (31.8%), indicated that the bird remains at the dam for seven months each year, arriving in October and departing at the end of April. This period corresponds to that reported by the majority of commercial fishermen ($n=3$; 37.5%) and recreational fishermen ($n=25$; 31.2%). In category B, 12 fishermen (13.6%) stated that the residency lasts six months, from October to the end of March. Alternatively, seven fishermen (7.95%) in category C reported an eight-month residency, from October to the end of May. The longest

period was reported by category L, where two fishermen (2.27%) noted that the Great Cormorant stays for about nine months at the dam, arriving in late September and leaving in early June.

Perceived spatial distribution and habitat use of the Great Cormorant

Based on the fishermen's responses, data were collected regarding the geographical distribution of the Great Cormorant and its preferred habitats at Beni Haroun Dam. Survey results indicated agree-

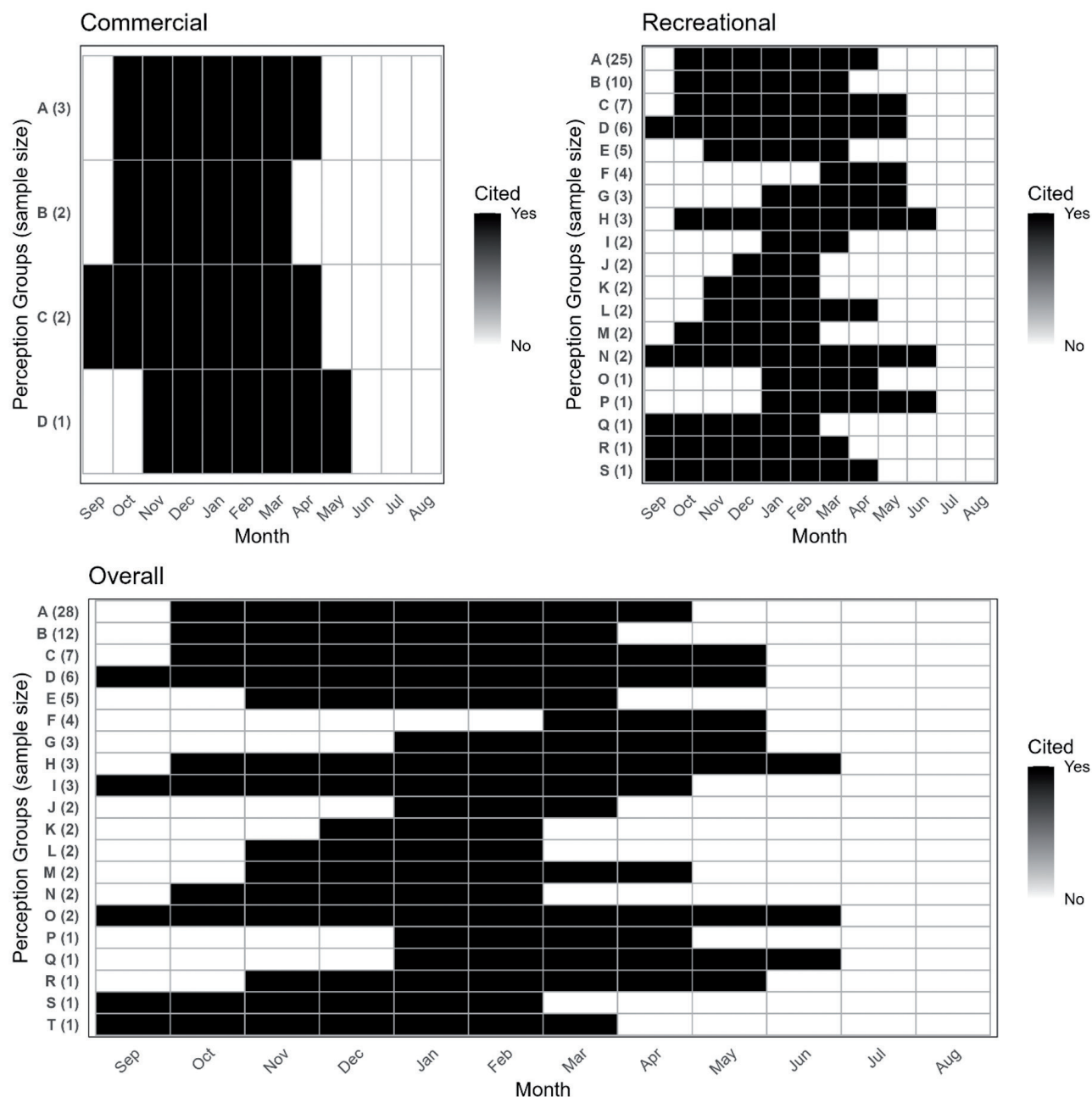


Fig. 3. Heatmaps demonstrating the monthly citation patterns of Great Cormorant presence, stratified by fishing purpose (commercial, recreational, and overall). Each row represents a separate perception group (designated A-Z), defined by a unique combination of months in which cormorants were reported as present. Groups are arranged by frequency, with Group A reflecting the most popular pattern. Shaded cells show months where presence was cited ("yes"), while white cells indicate months where it was not ("no").

ment between commercial and recreational fishermen, as 59 fishermen (68.6%) reported that this species is most concentrated in the western part of the dam (Oued Endja area), while 45 fishermen (52.3%) indicated a presence in the eastern part (Oued Rhumel area), and 15 fishermen (17.4%) noted that the central part of the dam (Sidi Marouane area) supports the highest numbers (Fig. 4).

With regard to the types of habitats in which the Great Cormorant is observed at Beni Haroun Dam, fishermen reported that trees were the most commonly used habitat ($n=77$; 87.5%), followed by banks ($n=38$; 43.2%), shallow waters ($n=37$; 42%), and deep waters ($n=34$; 38.6%) (Fig. 5). Riverbeds were reported less frequently ($n=24$; 27.3%), with a discrepancy between the two groups of fishermen: commercial fishermen reported sightings in riverbeds more often ($n=5$; 62.5%) than recreational fishermen ($n=19$; 23.8%). Finally, other less common habitats were mentioned, such as islands within the dam ($n=1$; 1.1%).

Fishermen's perceptions of Great Cormorant prey species selection

Based on interviews conducted with fishermen at Beni Haroun Dam, most respondents ($n=1$; 35.23%) indicated that the Great

Cormorant preys upon five of the six fish species targeted by fishermen, with the exception of *Rutilus rutilus*. These species include *Barbus barbus*, *Cyprinus carpio*, *Abramis brama*, *Perca fluviatilis*, and *Carassius carassius*.

Barbus barbus appeared as the most frequently mentioned and preferred prey for the Great Cormorant, as reported by the majority of fishermen, with the highest citation rate (63.64%). This proportion was distributed as 62.5% among commercial fishermen and 63.75% among recreational fishermen, indicating a consistent perception of predation across both groups. *Cyprinus carpio* and *Abramis brama* followed closely, generally ranked second and third in both citation frequency and preference.

Cormorant diet perceptions: prey size, daily food intake, and consumption rate

The majority of surveyed fishermen consider that the Great Cormorant primarily targets small-sized prey. Indeed, 78 respondents (88.6%) reported that this bird predominantly preys on small-sized fish. In contrast, only one fisherman (1.1%) believed that cormorants favor large-sized prey. A minority group of seven fishermen (8.0%) indicated that the cormorant feeds indiscrimi-

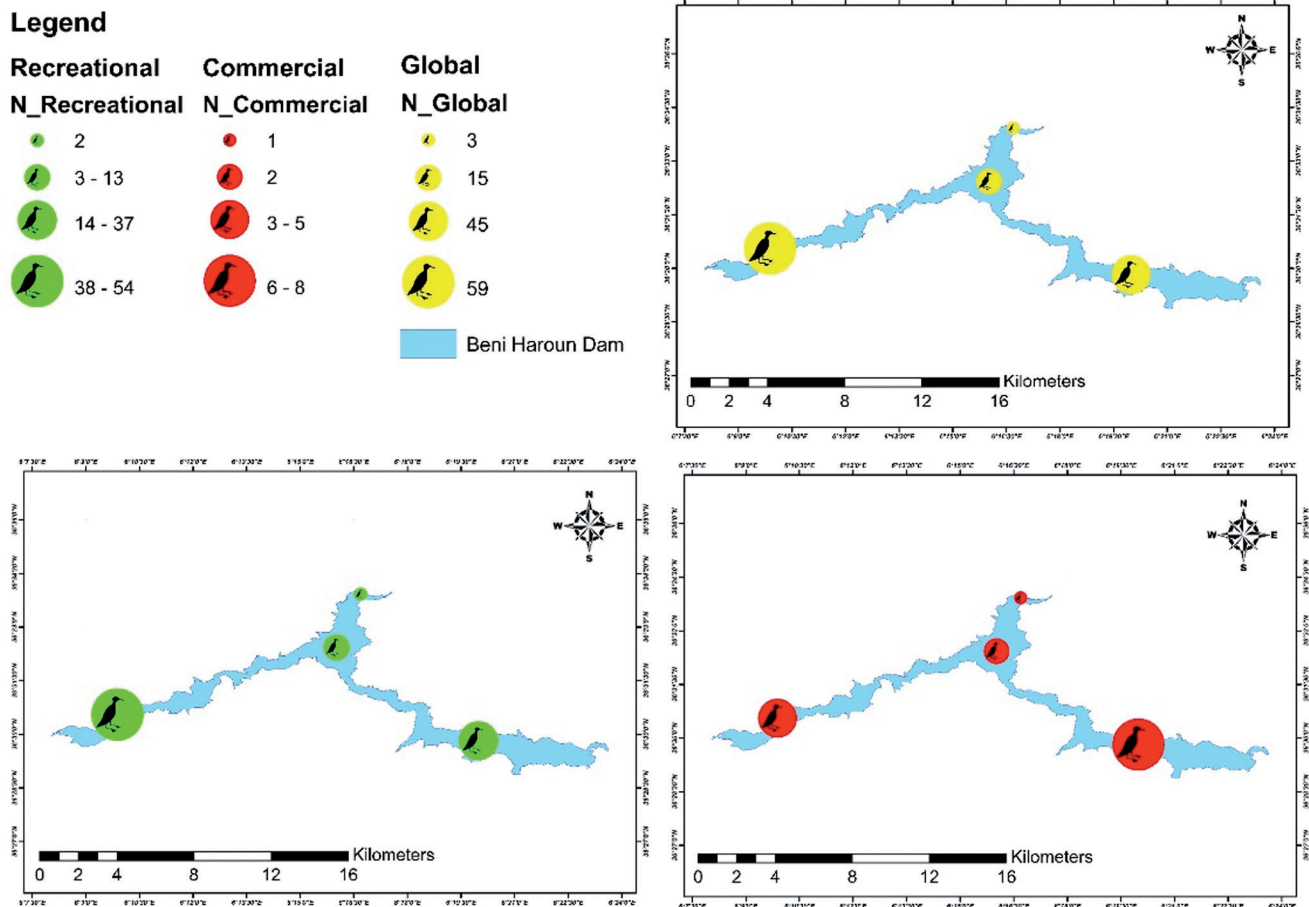


Fig. 4. Spatial distribution of Great Cormorant observations reported by fishermen at Beni Haroun Dam. Circle sizes represent observer counts: (A) global (yellow), with principal concentrations in western (59 observers) and eastern (45 observers) sectors; (B) recreational fishermen (green), showing broader distribution; (C) commercial fishermen (red), indicating restricted coverage with maximum 6-8 observers. Scale bar: kilometers.

nately of size. Additionally, two fishermen (2.3%) were unable to specify the size of the fish targeted by Great Cormorants. Both recreational and commercial fishermen agreed that cormorants prefer small-sized fish: 90.0% of recreational fishermen (72/80) and 75.0% of commercial fishermen (6/8) held this view. Among recreational fishermen, 8.75% (7/80) indicated that cormorants feed indiscriminately of size, while one (1.25%) did not provide an answer. Among commercial fishermen, one (12.5%) believed cormorants target large fish, and one (12.5%) did not provide an answer.

Regarding fish consumption, 22 fishermen (25%) reported being unable to accurately estimate the daily food intake (DFI), that is, the number of kilograms consumed daily by the Great Cormorant. The estimated values provided by fishermen ranged from a minimum of 0.5 kg to a maximum of 8 kg, resulting in a mean daily intake of 2.27 kg (± 1.32). These results closely matched the estimates from recreational fishermen, whereas among commercial fishermen, the minimum value reported was 1 kg and the maximum 3.5 kg, with a higher mean daily consumption of 2.43 kg (± 0.98).

Concerning the number of fish consumed daily by the Great Cormorant, fishermen's estimates ranged from 2 as the minimum to 25 as the maximum, with an average of approximately 8 fish per day (± 4.27). These figures were also similar to the recreational fishermen's responses. However, according to commercial fishermen, the minimum number consumed daily was 4 fish, with a maximum of 12 and an average daily consumption of about 8 fish (± 3.02).

Perceived foraging behavior and activity patterns of the Great Cormorant

Regarding the foraging behavior of the Great Cormorant, fishermen's responses were divided into three main categories: the majority of participants (first category) reported that this species forages

alone ($n=57$; 64.77%), followed by those who observed that the bird hunts in groups ($n=19$; 21.59%), while a minority (third category) indicated that the Great Cormorant forages both solitarily and in groups ($n=12$; 13.64%). The responses from both recreational and commercial fishermen reflected a similar distribution pattern, with a predominance for the first category, followed by the second and third categories, respectively.

When asked about the timing of the cormorants' feeding activity, 87 fishermen provided a response, while one recreational fisherman did not specify a foraging time period. The most common response was that the Great Cormorant hunts during both the morning and evening periods ($n=40$; 45.45%), followed by the answer that it feeds throughout the day without a specific time ($n=20$; 22.73%), then exclusively in the evening ($n=14$; 15.91%), exclusively in the morning ($n=10$; 11.36%), only in the afternoon ($n=2$; 2.27%), and finally both in the afternoon and evening ($n=1$; 1.14%). There was agreement between the recreational and commercial fishermen that the morning and evening are the main periods of foraging activity. However, the response "foraging only in the morning" ranked second among commercial fishermen, while "foraging throughout the day" was the next most common answer among the recreational group.

Attitude scale validity and distribution of fishermen's attitudes toward cormorants

The seven-item attitude scale demonstrated good internal consistency ($\alpha = 0.837$, standardized $\alpha = 0.847$). The Shapiro-Wilk test indicated that mean attitude scores departed from normality ($W = 0.906$, $p < 0.001$). The chi-square goodness-of-fit test revealed an unequal distribution of attitudes across the sample ($\chi^2(2, n=88) = 35.75$, $p < 0.001$). The dominant attitude category was positive ($n=55$; 62.5%), followed by moderate ($n=22$; 25.0%) and negative ($n=11$;

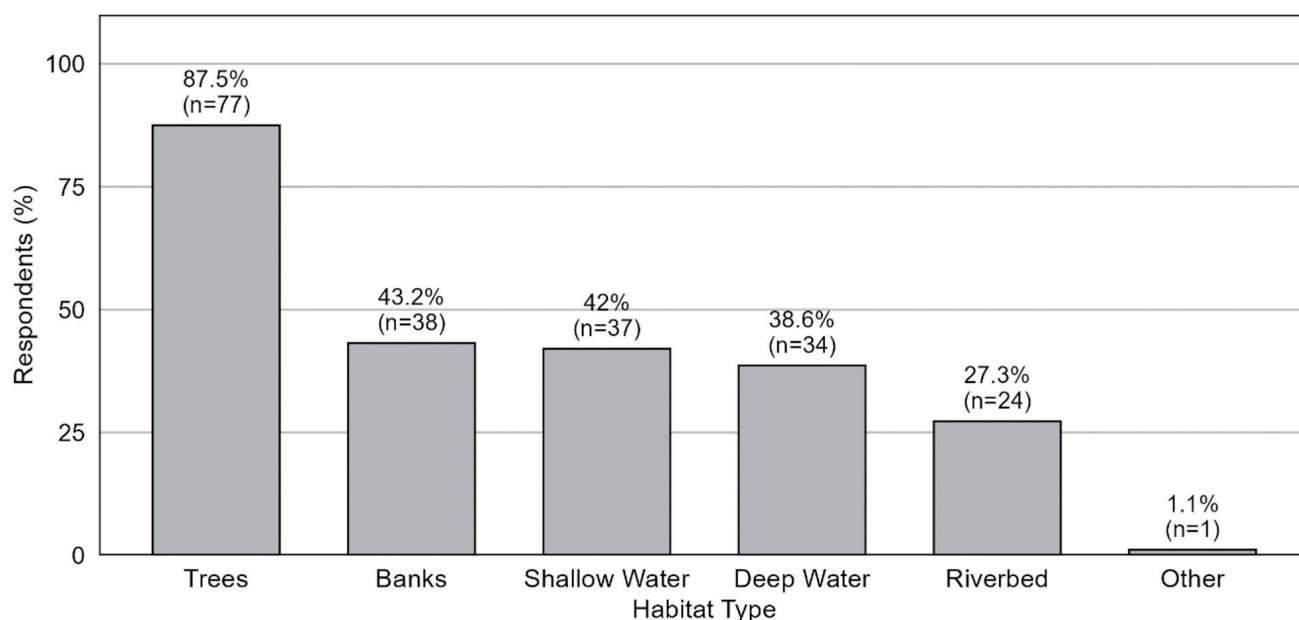


Fig. 5. Bar plot depicting the proportion of respondents who identified distinct habitat types as being exploited by Great Cormorants. Habitats are sorted in descending order of citation frequency. Values denote the percentage of the entire sample (n) and the absolute count of respondents for each category. "Trees" was the most often reported habitat, followed by "Banks" and "Shallow Water".

12.5%). Taken together, 87.5% of respondents held moderate to positive attitudes toward cormorants (Fig. 6).

Kruskal-Wallis tests revealed no differences in attitude scores by residence ($H(7) = 5.107$, $p=0.647$), education level ($H(3) = 1.276$, $p=0.735$), or fishing effort category ($H(2) = 0.397$, $p=0.820$). Mann-Whitney U tests indicated no differences in attitude scores by internet access ($W = 865.5$, $p=0.263$), fishing for consumption ($W = 942.5$, $p=0.765$), or fishing purpose ($W = 315.5$, $p=0.954$). Spearman rank correlations showed no associations between attitude scores and age ($\rho = -0.062$, $p=0.568$), number of children ($\rho = 0.016$, $p=0.890$), years of fishing experience ($\rho = -0.028$, $p=0.796$), or hours fished per session ($\rho = -0.107$, $p=0.322$).

DISCUSSION

Accuracy of local nomenclature as an indicator of ecological knowledge

The recognition rate of 97.7% for the Great Cormorant (*Phalacrocorax carbo*) among fishermen at Beni Haroun Dam falls within the high values reported for avian species viewed as having economic or cultural influence. Several recent ethno-ornithological studies suggest that when fishermen are routinely exposed to locally abundant piscivorous birds, recognition rates can surpass 90% (Vieite *et al.*, 2022; Katselis *et al.*, 2023). The diversity of the docu-

mented local names (ten distinct appellations) reflects the richness of local popular nomenclature and aligns with patterns observed in ethnobiology, where vernacular name diversity correlates positively with the ecological and cultural importance of species (Jarić *et al.*, 2016; Gosler, 2017; Medeiros, 2022).

Beyond overall name diversity, the accuracy of the cited names relative to established nomenclature offers further insight into the depth of local ecological knowledge. Of the 54 fishermen who offered a name for the species, we consider four appellations to be accurate: “Al-ghaq” /al’ya:q/, a shortened form of “Al-ghaq al-kabir” /al’ya:q alka’bi:r/, the standard Arabic name recorded for the Great Cormorant in international databases (Avibase, 2025); “Ghorab al-ma” /yu’ra:b al’ma:/, closely paralleling “Ghorab al-bahr” /yu’ra:b al’bahr/ (Sea Raven) and, notably, the etymological root of the genus name *Phalacrocorax* itself, derived from the Ancient Greek *phalakrós* (bald) and *kórax* (raven or crow); “Tair al-assouad” /al’ t’ajr al’ aswad/ (“the black bird”), which aligns closely with the specific epithet *carbo* (Latin for coal or charcoal, referencing the bird’s dark plumage); and “Al-ghattas” /al’yu.t’a:s/ (“the diver”), which accurately reflects the species’ characteristic diving foraging behavior. Together, these four names accounted for 30 of the 54 responses (55.6%).

In contrast, we consider the remaining names to be inaccurate. In particular, “Al-ghora” /al’ yurra/ is, in fact, the established Arabic name for the Eurasian Coot (*Fulica atra*) (Avibase, 2025), a differ-

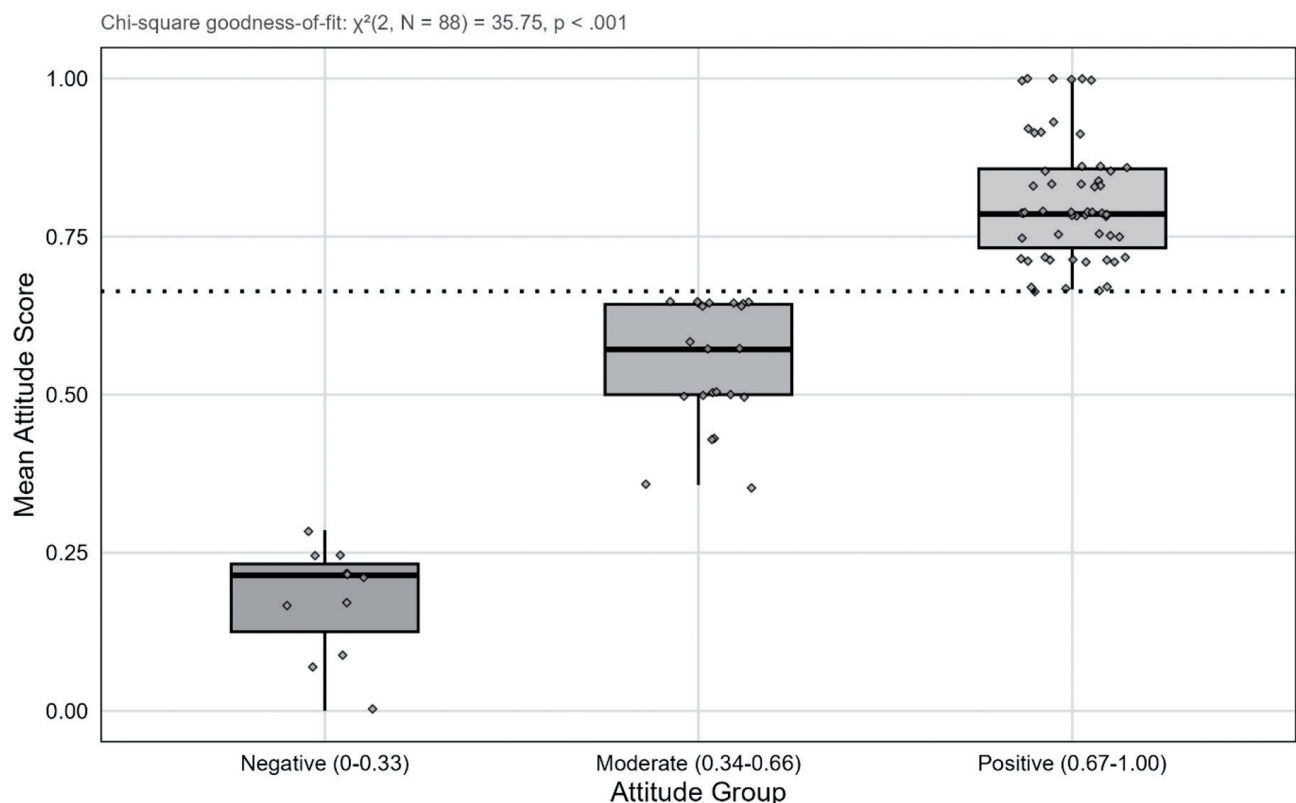


Fig. 6. Distribution of mean attitude ratings across three attitude groups (negative, moderate, positive) toward cormorants among fishermen at Beni Haroun dam ($n=88$). Boxplots depict median (thick horizontal line), interquartile range (box), and whiskers extending to $1.5\times$ the interquartile range. Individual data points (jittered) indicate individual responses. The black dotted line reflects the general average of the mean attitude score (average = 0.663), with the majority of respondents (62.5%) falling into the positive attitude category.

ent species entirely, indicating a degree of taxonomic confusion among the fishermen who used this term. The names “Al-brak” /al'bara:k/ which means (duck), “Al-marzouk” /almar'zu:q/, “Sardana” /sar'da:na/, and “Tair al-ma” /t'ajr al'ma:/ do not correspond to recognized Arabic designations for the Great Cormorant and are similarly considered inaccurate or non-standard.

Taken together, the combination of near-universal visual recognition (97.7%) with a moderate proportion of etymologically and taxonomically accurate naming (55.6% of named responses) suggests that fishermen at Beni Haroun Dam possess a moderate to relatively high level of local ecological knowledge regarding this species' identity, even where vernacular terminology diverges from standardized nomenclature.

Population trends and seasonality in light of regional cormorant ecology

The majority of fishermen reported an increase in Great Cormorant populations (60.2% total, 87.5% commercial, 57.5% recreational). This observation coincides with previous demographic trends for *Phalacrocorax carbo sinensis*, including the rapid increase in the eastern Baltic and pan-European region (Van Eerden *et al.*, 2022a; Van Eerden *et al.*, 2022b). We consider this perception broadly accurate, as it aligns qualitatively with confirmed pan-European population growth, though our survey did not specify a timeframe over which this increase was perceived, limiting direct quantitative comparison. Expanding cormorant populations have escalated confrontations with fisheries, particularly in constructed habitats such as dams (Katselis *et al.*, 2023). The perceptual disparity between commercial (87.5%) and recreational (57.5%) fishermen reflects sensitivity linked to economic risks, corroborating findings that perceived conflict severity changes with stakeholder interests (Ekblad *et al.*, 2025). These demographic insights are particularly relevant in the Mediterranean, where scientific data on wintering populations remain scarce (Carss, 2022).

31.8% of fishermen reported observing the Great Cormorant from October to the end of April, with a winter peak in January–February (95.4%), which corresponds to the winter temporal distribution patterns documented for the species in the Mediterranean and North Africa (Van Eerden *et al.*, 2022a; Katselis *et al.*, 2023). This seven-month presence period coincides with scientific data on species migration, which shows autumnal arrival and departure in early spring (Adalsteinsson *et al.*, 2023). However, this duration exceeds the residence period recorded by Benmetir *et al.* (2020) in their study conducted in eastern Algeria.

The reported differences in residence duration (6 to 9 months according to fishermen) exceed scientific estimates of ~4.5 months (136 days) for Mediterranean wintering populations (Frederiksen *et al.*, 2018). We consider these estimates inaccurate in quantitative terms, overestimating residency by a factor of roughly 1.3 to 2, though they remain qualitatively correct in identifying winter as the peak presence period and January–February as the seasonal high point. While fishermen's calculations extend beyond known averages, they accurately capture the extended temporal distribution of the species, including the winter concentration peak reported in January–February during pan-European censuses. Recent research confirms that cormorants wintering in the Mediterranean and North Africa originate primarily from breeding populations of Northern and Eastern Europe, with site fidelity driven by favorable thermal conditions (average temperature above -5°C) and continuous food availability (Van Eerden *et al.*, 2022a). This comparison shows that fishermen's ecological knowledge parallels the qualitative reality of

seasonal abundance and extended presence, even if quantitative precision varies.

Habitat Selection and Spatial Ecology of the Great Cormorant at Beni Haroun Dam

The difference in the spatial distribution of the Great Cormorant at Beni Haroun Dam, with preferential concentration in the western (68.6% of fishermen) and eastern (52.3%) parts, compared to the central part (17.4%), reflects typical habitat selection patterns of the species documented in recent literature on artificial aquatic ecosystems. We consider this spatial perception accurate, as it matches the documented preference of the species for river-mouth and shallow littoral zones over open central-reservoir waters. This uneven distribution is mostly explained by the selection of shallow-water zones with high prey density, as indicated by Gwiazda and Flis (2022), who affirms that cormorants favor locations where water is shallow and transparent to enhance hunting effectiveness. Fishermen's observations are consistent with recent research on European reservoirs, where cormorants demonstrate a predilection for convergence zones of river streams and shallow littoral areas (Kucherenko, 2023; Golubev, 2024). The favored concentration in mouth zones (Oued Endja and Oued Rhumel) corresponds to trends seen in other European reservoirs, where these sectors offer habitat diversity and good accessibility to fish resources (Saarikoski *et al.*, 2024).

The preference for trees (87.5%) as resting, feather-drying, and communal roosting sites aligns with habitat-selection patterns documented in artificial aquatic systems (Emmrich and Düttmann, 2011; Golubev, 2024; Sydorenko, 2025), meeting the species' behavioral requirements for thermoregulation and maintaining plumage waterproofing after dives (Čech and Vejřík, 2011; Cook *et al.*, 2020). This habitat-use report is likewise consistent with the literature and considered accurate. The complementary use of banks (43.2%) also strengthens these thermoregulatory functions, whilst exploitation of shallow waters (42%) corresponds to optimal foraging zones where underwater visibility and prey accessibility are maximized (Källo *et al.*, 2020; Gwiazda and Flis, 2022). The gap in observations on rocky substrates between commercial and recreational fishermen (62.5% vs. 23.8%) presumably reflects unequal fishing effort and accessibility, as both groups operate in different ecosystems (Hansen, 2021; Saarikoski *et al.*, 2024). This multi-habitat distribution highlights the species' adaptation strategy of spatially separating resting, thermoregulation, and feeding functions to enhance energetic efficiency in artificial aquatic habitats (Peck-Richardson *et al.*, 2018).

Corroborating fishermen's prey species reports with diet literature

Local fishermen describe the Great Cormorant as a generalist predator, as it preys on five of the six targeted fish species (with the exception of *Rutilus rutilus*). Our results include one additional species (*Perca fluviatilis*) compared to a previous study conducted in Beni Haroun Dam on the diet of the Great Cormorant, which reported four main fish species as its primary winter prey: *Barbus barbus*, *Cyprinus carpio*, *Abramis brama*, and *Carassius carassius*, with *B. barbus* being the most common and widespread species (Belfethi and Moulai, 2022). We consider fishermen's prey-species reports largely accurate, as four of the five cited species directly corroborate pellet-based evidence; the fifth (*Perca fluviatilis*) cannot be confirmed or refuted from existing local data but is not implausible given the species' known diet elsewhere.

Notably, however, both fishermen and Belfethi and Moulai (2022) exclude *R. rutilus* from the Great Cormorant's diet at Beni Haroun Dam, despite this species being reported as the most abundant prey item in the cormorant's diet in several other studies (Čech *et al.*, 2008; Čech and Vejřík, 2011). Given the Great Cormorant's well-documented status as a generalist and opportunistic forager, this consistent absence across both local ecological knowledge and pellet-based sampling is unlikely to reflect a shared blind spot in either method, and more plausibly indicates comparatively low local abundance or accessibility of *R. rutilus* at this reservoir relative to other systems, rather than a genuine gap in fishermen's or researchers' knowledge.

This disparity underlines the relevance of local ecological knowledge in providing a more complete picture of species interactions. While Belfethi and Moulai (2022) identified four main fish species based on 75 pellets taken between October and January, our interviews with fishermen showed five prey species, including *P. fluviatilis* (Salmi *et al.*, 2015; Traczkuk *et al.*, 2021). This difference presumably derives from the narrow temporal span of the previous study, which did not cover the complete wintering season. Fishermen's year-round observations at the dam thus offered larger temporal coverage and revealed prey species that shorter-term scientific sampling may miss due to changes in diet between sites and seasons (Santoul and Mastroiello, 2004).

Fishermen indicated that *B. barbatus* was the most frequently hunted fish species by the Great Cormorant, which is consistent with the findings of Belfethi and Moulai (2022). This pattern may be attributable to the great abundance of this species and its ease of capture (Magath *et al.*, 2015).

Evaluating fishermen's estimates of prey size and daily food intake

Regarding the size of the fish captured by Great Cormorants during feeding, research has indicated that this species demonstrates selectivity in prey size based on seasonal fluctuations. The average weight of the collected fish grows substantially as temperatures decline. However, the Great Cormorant consumes larger amounts of somewhat larger prey as the season progresses from summer to winter (Čech *et al.*, 2008). Our data reveal that 88.6% of fishermen report that the Great Cormorant preys predominantly on small-sized fish, which is consistent with other prior research suggesting that Great Cormorants primarily feed on small fish (Gagliardi *et al.*, 2015; Traczkuk *et al.*, 2021; Lyach, 2022).

Local fishermen's estimates of the Great Cormorant's (*P. carbo*) daily fish consumption are generally higher than recent scientific measurements reported for the species in Europe and Africa, which typically range between 0.2 and 1.4 kg/day (Grémillet *et al.*, 2000; Traczkuk *et al.*, 2021; Dehnhard *et al.*, 2021). However, the observed range (0.5–8 kg, mean = 2.27 ± 1.32 kg) encompasses the maximum values documented locally at Beni Haroun Dam, where daily consumption varies from 0.57 to 2.35 kg/day depending on the analyzed pellets (Belfethi and Moulai, 2022), suggesting that fishermen's perceptions partially reflect real variability linked to local and seasonal conditions. This moderate overestimation, similar to that noted among Minho River fishermen (estimated mean of 1.96 kg/day vs lower published data) (Vieite *et al.*, 2022), often highlights cognitive biases in local ecological knowledge (LEK), amplified by perceived conflicts with fisheries, although commercial fishermen's estimates (2.43 ± 0.98 kg) align more closely with locally observed maxima.

Foraging behavior in comparative perspective

The observations made by fishermen at Beni Haroun Dam about the foraging habits of the Great Cormorant somewhat coincide with findings from current scientific literature. The predominance of responses indicating solitary hunting (64.77%) is consistent with the perspectives of fishermen along the Minho River in Portugal, where 88% describe mostly solitary activity, however adaptable depending on water turbidity or other environmental circumstances (Vieite *et al.*, 2022). We consider this reported foraging pattern accurate, as it matches both fisher-reported behavior elsewhere and confirmed behavioral flexibility in the species. In the Great Cormorant, such behavioral flexibility has been confirmed by recent research revealing that the species alternates between solitary and group foraging according to underwater visibility and prey quantity, particularly during wintering at lacustrine locales (Van Eerden and van Rijn, 2021). Regarding timing, the "morning and evening" modality (45.45%) reflects bimodal diurnal patterns observed in *P. carbo*, with crepuscular peaks that optimize energy efficiency, while the low frequency of responses indicating no specific foraging time (1.14%) highlights the species' adaptability to fluctuations in fish resources (Lyach *et al.*, 2018). This timing pattern is likewise consistent with documented crepuscular foraging peaks and is considered accurate.

Drivers of attitude uniformity toward the Great Cormorant

The Cronbach's alpha value obtained in the present study ($\alpha = 0.837$) indicates good internal consistency of the attitude scale, in accordance with the interpretive thresholds recommended by George and Mallery (2003), and is consistent with values reported in comparable attitude studies using Likert-based instruments for aquatic wildlife conservation (Braga and Schiavetti, 2013; Vieite *et al.*, 2022).

The results indicate that positive attitudes toward cormorants predominate among the fishermen community at Beni Haroun Dam, independent of fishing behavior. No changes in attitude scores were detected by fishing effort category, fishing for consumption, fishing purpose, years of fishing experience, or hours fished per session. This absence of antagonism likely reflects the largely recreational nature of fishing activity, where commercial fishermen constitute just a small fraction. Because commercial operators are small in number (DSPAM, 2025), the consequences of cormorant predation remain insufficient to yield quantifiable economic losses at the individual or collective level, which may explain why commercial fishermen also maintain tolerant attitudes toward *P. carbo*. Furthermore, high-effort fishermen incur minimal financial danger from cormorant predation and are thus protected from the economically driven concerns that elsewhere differentiate attitudes by fishing effort (Vieite *et al.*, 2022; Villar *et al.*, 2024). These findings contrast with the hostility typically reported in cormorant-fisheries conflict studies elsewhere, where professional and economic stakes consistently lead to strong negative attitudes and even support for lethal management among fishing communities (Peeva *et al.*, 2017; Liordos *et al.*, 2025).

The absence of associations between attitude scores and any socio-demographic variable suggests that positive attitudes are uniformly distributed across the fishermen community, regardless of age, number of children, education level, residence, or internet access. The absence of age-linked variation suggests that continued exposure to cormorants does not cause attitude shifts from

positive to negative in the absence of economic risks. Similarly, the absence of effects for education level and internet access suggests that neither formal knowledge acquisition nor exposure to readily available internet information significantly shifts attitudes, pointing instead to a shared local perception of the species that surpasses individual informational backgrounds. These findings contrast with previous research, as Vieite *et al.* (2022) found that older fishermen held more negative conservation attitudes, while Liordos *et al.* (2025) reported that lower education levels predicted greater endorsement of lethal management strategies among both fishermen and the general public.

Study limitations

This study has several limitations. First, participation was voluntary, and not all fishermen approached agreed to take part, so the sample may not fully represent the broader fishing community at the dam. Second, the relatively high mean age of respondents (53 years) reflects a genuine demographic pattern, as younger generations in the region appear less engaged in fishing; this is relevant given that Vieite *et al.* (2022) found that older fishermen held more negative conservation attitudes, suggesting age composition may be a meaningful factor in interpreting our results rather than merely a sampling artifact. Third, the study was restricted to a single reservoir (Beni Haroun Dam), and findings may not generalize to other Algerian or Mediterranean wetlands; multi-site studies are needed to assess this. Fourth, the imbalance between recreational ($n = 80$) and commercial fishermen ($n = 8$) reflects the limited number of commercial fishing permits issued in the region by the DSPAM, constraining the pool of eligible respondents; this imbalance should be considered when interpreting comparisons between the two groups. Finally, fishermen's prey-species identifications may be constrained by the brief and often distant visibility of captured fish during cormorant foraging; however, discrepancies between fishers' ecological knowledge and scientific data do not necessarily indicate fisher error, since fishers' observations often draw on long-term, cumulative experience that can complement or extend shorter-term scientific sampling (Silvano and Valbo-Jørgensen, 2008).

CONCLUSIONS

This study offers the first evaluation of Algerian fishing communities' local ecological knowledge and conservation attitudes regarding the Great Cormorant (*Phalacrocorax carbo*), a species that has been legally protected in Algeria since 2012. The results show that fishermen at Beni Haroun Dam have a high level of ecological knowledge about cormorant ecology, which frequently corresponds with scientific literature, although some perceptions, such as daily food intake and residency duration showed clear quantitative overestimation relative to published data. The identification of *Perca fluviatilis* as prey, absent from previous diet studies in the same study area, demonstrates how local knowledge can complement shorter-term scientific sampling, while predominantly positive (62.5%) to moderate (25.0%) attitudes toward conservation reflect the recreational nature of local fishing where limited commercial operations prevent measurable economic losses. The absence of substantial relationships between attitudes and socio-demographic characteristics shows equally distributed favorable perceptions, challenging the assumption that prolonged cormorant exposure invariably generates negative attitudes in the absence of economic incentives. These find-

ings indicate that human-wildlife coexistence depends on socio-economic context rather than resource competition alone, advocating for the integration of local ecological knowledge into Mediterranean inland fisheries conservation alongside context-specific management strategies that respect local perspectives while safeguarding both avian populations and fishing community practices.

REFERENCES

- Aðalsteinsson S, López A, Bregnballe T, 2023. Timing of spring migration of Norwegian Great Cormorants: long-term trends and effects of winter severity. *Seabird* 35:54-75.
- Agence Nationale des Barrages et Transferts (ANBT), 2014. [Résultats de la bathymétrie et du sonar latéral]. [in French]. Service d'exploitation du barrage de Beni Haroun.
- Avibase, 2025. Avibase - The World Bird Database. Lepage D, Birds Canada. Accessed: Mai 2025. Available from: <https://avibase.bsc-eoc.org/avibase.jsp?lang=EN>
- Belfethi L, Moulaï R, 2022. Diet, prey selection and biomass consumption of the Great Cormorant (*Phalacrocorax carbo*) in Algeria. *Zoodyversity* 56:57-66.
- Benmetir S, Bediaf S, Bouchecker A, Gherib A, Lazli A, 2020. [Données préliminaires sur l'hivernage du Grand Cormoran [*Phalacrocorax carbo* (Linnaeus, 1758)] dans la Numidie orientale (nord-est algérien)]. [Article in French]. *Bull Soc Zool Fr* 145:155-167.
- Bensaci E, Saheb M, Nouidjem Y, Bouzegag A, Houhamdi M, 2013. [Biodiversité de l'avifaune aquatique des zones humides sahariennes: cas de la dépression d'Oued Righ (Algérie)]. [Article in French]. *Physio-Geo* 7:211-222.
- Bouchareb N, Chouaib RA, Meriem L, Abdelaziz B, Salah K, Sara B, Mohamed C, 2025. Monitoring water quality in Beni Haroun Dam, Northeastern Algeria: application of Water Quality Index (WQI), Pollution Index (PI), and statistical analyses. *Desalin Water Treat* 323:101267.
- Bouldjedri M, Mayache B, 2020. Structure of waterbird assemblages in fragmented coastal wetlands of Northeastern Algeria. *Arx Misc Zool* 18:123-142.
- Braga HO, Pardo MÂ, da Cruz RCM, Alvarenga TC, Azeiteiro UM, 2018. Fishers' knowledge in Southeast Brazil: the case study of the Brazilian sardine. *Ocean Coast Manage* 165:141-153.
- Braga HO, Schiavetti A, 2013. Attitudes and local ecological knowledge of expert fishermen in relation to conservation and bycatch of sea turtles (Reptilia: *Testudines*), Southern Bahia, Brazil. *J Ethnobiol Ethnomed* 9:15.
- Carss DN, 2022. There must be some kind of way out of here: towards 'reframing' European cormorant-fisheries conflicts. *Ardea* 109:667-681.
- Carss DN, Bell S, Marzano M, 2009. Competing and coexisting with cormorants: ambiguity and change in European wetlands, p. 99-121. In: S. Heckler (ed.), *Landscape, process and power*. Berghahn Books.
- Čech M, Čech P, Kubečka J, Prchalová M, Drašík V, 2008. Size selectivity in summer and winter diets of Great Cormorant (*Phalacrocorax carbo*): does it reflect season-dependent difference in foraging efficiency? *Waterbirds* 31:438-447.
- Čech M, Vejřík L, 2011. Winter diet of Great Cormorant (*Phalacrocorax carbo*) on the River Vltava: estimate of size and species composition and potential for fish stock losses. *Folia Zool* 60:129-142.
- Chabou S, Khammar H, Hadjab R, Saheb M, 2020. Avifauna composition of two natural and artificial wetlands in Jijel region of North-eastern Algeria (the Beni Haroun Dam and Redjla Marsh). *Ecol Env Conserv* 26:1435-1449.

- Chebbah L, Kabour A, 2023. Characterization of leakage water flows in the subsoil of Beni Haroun dam by hydrogeological approach. *Acta Hydrol Slovaca* 24:14-23.
- Cheung FM, van de Vijver FJR, Leong FTL, 2011. Toward a new approach to the study of personality in culture. *Am Psychol* 66: 593-603.
- Collas M, Burgun V, 2011. Development of Great Cormorant population (*Phalacrocorax carbo sinensis*) in North-East France: synthesis of long-term monitoring (1997-2008). *Knowl Manag Aquat Ec* 403:05.
- Cook TR, Martin R, Roberts J, Häkkinen H, Botha P, Meyer C, Sparks E, Underhill LG, Ryan PG, Sherley RB, 2020. Parenting in a warming world: thermoregulatory responses to heat stress in an endangered seabird. *Conserv Physiol* 8:coz109.
- Cronbach LJ, 1951. Coefficient alpha and the internal structure of tests. *Psychometrika* 16:297-334.
- Dehnhard N, Langset M, Aglen A, Lorentsen S-H, Anker-Nilssen T, 2021. Fish consumption by Great Cormorants in Norwegian coastal waters - a human-wildlife conflict for wrasses, but not gadids. *ICES J Mar Sci* 78:1074-1089.
- DGF, 2013. [Dénombrement hivernale des oiseaux d'eau en Algérie]. [in French]. Direction générale des forêts.
- DGF, 2018. [Dénombrement hivernale des oiseaux d'eau au Barrage Beni Haroun]. [in French]. Direction générale des forêts, Conservation des forêts de la Wilaya de Mila.
- Dinesen GE, Andersen SF, Worsaae K, Støttrup JG, 2024. Cormorant management in Denmark: a retrospective analysis using the Systems Approach Framework. *Ocean Coast. Manage.* 257:107319.
- Direction de la pêche et de l'aquaculture de la wilaya de Mila (DSPAM), 2025. [Rapports et statistiques internes 2025]. [in French]. Station de pêche et d'aquaculture de la wilaya de Mila, Algérie.
- Ekblad C, Westerborn M, Laaksonen T, Kankainen M, Ovaskainen A, Sinisalo S, Jormalainen V, 2025. Great cormorants and grey herons depredating at finfish aquaculture: factors affecting the human-wildlife conflict. *Ambio* 55:164-175.
- Emmrich M, Düttmann H, 2011. Seasonal shifts in diet composition of Great Cormorants *Phalacrocorax carbo sinensis* foraging at a shallow eutrophic inland lake. *Ardea* 99:207-216.
- Ferroukhi SA, Bouzid A, Grimes S, Kaabache R, Lazereg M, Tifouri M, 2022. [Les politiques de soutien à l'agriculture et la pêche en Algérie: une prospective stratégique vers la sécurité alimentaire durable 2035]. [Article in French]. *Cah CREAD* 38:379-412.
- Fox J, Weisberg S, 2018. *An R companion to applied regression*. Sage Publications.
- Frederiksen M, Korner-Nievergelt F, Marion L, Bregnballe T, 2018. Where do wintering cormorants come from? Long-term changes in the geographical origin of a migratory bird on a continental scale. *J Appl Ecol* 55:2019-2032.
- Gagliardi A, Preatoni DG, Wauters LA, Martinoli A, 2015. Selective predators or choosy fishermen? Relation between fish harvest, prey availability and Great Cormorant (*Phalacrocorax carbo sinensis*) diet. *Ital J Zoo.* 82:544-555.
- George D, Mallery P, 2003. *SPSS for Windows step by step: a simple guide and reference*. Boston, Allyn & Bacon.
- Golubev S, 2024. Development of the Rybinsk Reservoir by the Great Cormorant *Phalacrocorax carbo* in Russia, 1941-2024. *Species* 25:1-7.
- Golubkov MS, Golubkov SM, 2024. Secchi disk depth or turbidity, which is better for assessing environmental quality in eutrophic waters? A case study in a shallow hypereutrophic reservoir. *Water* 16:18.
- Gosler AG, 2017. The human factor: ecological salience in ornithology and ethno-ornithology. *J Ethnobiol* 37:637-662.
- Grémillet D, Storch S, Peters G, 2000. Determining food requirements in marine top predators: a comparison of three independent techniques in Great Cormorants, *Phalacrocorax carbo carbo*. *Can J Zool* 78:1567-1579.
- Gwiazda R, Flis A, 2022. Studies of food ecology of Great Cormorant *Phalacrocorax carbo* in relation to water transparency require system-adjusted data: an example from two Polish reservoirs. *Ardea* 109:529-536.
- Habila S, Leghouchi E, Valdehita A, Bermejo-Nogales A, Khelili S, Navas JM, 2017. Induction of EROD and BFCOD activities in tissues of barbel (*Barbus callensis*) from a water reservoir in Algeria. *Ecotoxicol Environ Saf* 142:129-138.
- Hansen OK, 2021. Can cormorants be used as indicators of local fish abundances? A diet study of cormorants on Gotland. Degree Project, Uppsala University.
- Harding LE, Mesler JJ, 2022. Cormorant abundance, diet, and foraging habits in Arizona. *J Field Ornithol* 93:6.
- Jarić I, Courchamp F, Gessner J, Roberts DL, 2016. Data mining in conservation research using Latin and vernacular species names. *PeerJ* 4:e2202.
- Kabour A, Chebbah L, 2023. Temporal evaluation of the Beni Haroun dam's (Algeria) raw water quality, through a literature review. *Environ Res Tec* 6:248-257.
- Källo K, Baktoft H, Jepsen N, Aarestrup K, 2020. Great Cormorant (*Phalacrocorax carbo sinensis*) predation on juvenile down-migrating trout (*Salmo trutta*) in a lowland stream. *ICES J Mar Sc.* 77:721-729.
- Källo K, Birnie-Gauvin K, Jepsen N, Aarestrup K, 2023. Great Cormorant (*Phalacrocorax carbo sinensis*) predation on adult anadromous brown trout (*Salmo trutta*). *Ecol Freshw Fish* 32:488-495.
- Katselis G, Konostas S, Moutopoulos DK, 2023. Estimation of fishery losses from Great Cormorants during the wintering period in Greek lagoons (Ionian Sea, W. Greece). *Sustainability* 15:12007.
- Kucherenko VM, 2023. The diversity-area relationship for waterbird communities in small artificial reservoirs over winter. *J Vertebr Biol* 72:23023.
- Liordos V, Kontsiotis VJ, Karras G, Kyriakidou C, Karris G, 2025. Attitudes toward managing a fish-eating predator, the Great Cormorant, in a coastal environment. *Diversity* 17:306.
- Lych R, 2022. Do cormorants and recreational anglers take fish of the same species and sizes? *Ardea* 109:629-638.
- Lych R, Blabolil P, Čech M, 2018. Great Cormorants *Phalacrocorax carbo* feed on larger fish in late winter. *Bird Study* 65:249-256.
- Magath V, Abraham R, Helbing U, Thiel R, 2015. Link between estuarine fish abundances and prey choice of the Great Cormorant *Phalacrocorax carbo* (Aves, Phalacrocoracidae). *Hydrobiologia* 763:313-327.
- Marouf N, Remini B, 2019. Impact study of Beni-Haroun dam on the environmental and socio-economic elements in Kébir-Rhumel basin, Algeria. *J Water Land Dev* 43:120-132.
- Medeiros MC, Pinto AS, dos Santos DR, Martel G, de F Lopes S, da S Mourão J, 2022. Folk taxonomy and scientific nomenclature: working together for conservation of fishery resources in Brazil. *J Nat Conserv* 68:126214.
- Peck-Richardson A, Lyons D, Roby D, Cushing D, Lerczak J, 2018. Three-dimensional foraging habitat use and niche partitioning in two sympatric seabird species, *Phalacrocorax auritus* and *P. penicillatus*. *Mar Ecol Prog Ser* 586:251-264.
- Peeva SP, Raichev EG, Zhelyazkov GI, 2017. Fish producers' attitudes to the most common fish-eating birds in Central Bulgaria. *Ecol Balk* 9:1-5.
- Pimenta VRA, Rodrigues Filho JL, Ataides JS, Branco JO, 2024. Human-wildlife conflict between Neotropical cormorant and arti-

- sanal fisheries induces dubious management policies in southern Brazil. *Ocean Coast. Res* 72:e24011.
- R Core Team, 2025. R: a language and environment for statistical computing. Version 4.4.3. Vienna, R Foundation for Statistical Computing.
- Rebbah AC, Bouchareb N, Lalaoui M, Bouarroudj S, Bouzegag A, Chebbah M, 2025. Impact of physico-chemical parameters on the spatial distribution of phytoplankton in Beni Haroun Dam (Mila, Northeastern Algeria). *Egypt. J Aquat Biol Fish* 29:969-988.
- République Algérienne (JORA), 2012. [Décret exécutif n° 12-235 du 3 Rajab 1433 correspondant au 24 mai 2012 fixant la liste des espèces animales non domestiques protégées]. [in French]. *Journal Officiel de la République Algérienne* 35:4-12.
- Revelle W, 2023. psych: procedures for psychological, psychometric, and personality research. R package version 2.3.6. Evanston, Northwestern University.
- Saarikoski H, Vikström S, Peltonen L, 2024. Knowledge co-production around the cormorant-fishing conflict using a joint fact-finding approach. *Environ Sci Poll* 151:103628.
- Salmi JA, Auvinen H, Raitaniemi J, Kurkilahti M, Lilja J, Maikola R, 2015. Perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) in the diet of the Great Cormorant (*Phalacrocorax carbo*) and effects on catches in the Archipelago Sea, Southwest coast of Finland. *Fish Res* 164:26-34.
- Samraoui F, Alfarhan AH, Al-Rasheid KAS, Samraoui B, 2011. An appraisal of the status and distribution of waterbirds of Algeria: indicators of global changes? *Ardeola* 58:137-163.
- Santoul FH, Mastrotillo S, 2004. Diet of Great Cormorants *Phalacrocorax carbo sinensis* wintering in Malause (South-West France). *Arch Hydrobiol* 160:281-287.
- Silvano RAM, Valbo-Jørgensen J, 2008. Beyond fishermen's tales: contributions of fishers' local ecological knowledge to fish ecology and fisheries management. *Environ Dev Sustain* 10:657-675.
- Sydorenko AI, 2025. Typology of Great Cormorant (*Phalacrocorax carbo*) nesting colonies in the Azov-Black Sea region of Ukraine. *J V.N. Karazin Kharkiv Natl Univ Ser Biol* 44:95-112.
- Tandjir L, 2008. [Exploitation piscicole du barrage Guenitra (Oum Toub, Skikda, Algérie)]. [Article in French]. *Int J Environ Stud* 65:705-714.
- Traczuk P, Ulikowski D, Kalinowska K, 2021. Stomach contents of the Great Cormorant *Phalacrocorax carbo* inhabiting northeastern Poland. *Fish Aquat Life* 29:202-210.
- Van Eerden MR, van Rijn S, 2021. Social hierarchy within communal foraging flocks of Great Cormorants *Phalacrocorax carbo* as reflected by differences in prey composition and food intake at the roost. *Ardea* 109:549-563.
- Van Eerden MR, Parz-Gollner R, Marion L, Bregnballe T, Paquet J-Y, Volponi S, van Rijn S, Carss DN, 2022a. Numbers of Great Cormorants *Phalacrocorax carbo* wintering in the Western Palaearctic in January 2013. *Ardea* 109:271-284.
- Van Eerden MR, van Rijn S, Kilpi M, Lehtikoinen A, Lilleleht V, Millers K, Gaginskaya A, 2022b. Expanding east: Great Cormorants *Phalacrocorax carbo* thriving in the Eastern Baltic and Gulf of Finland. *Ardea* 109:313-326.
- Vieite B, Braga HO, Costa Neto EM, Azeiteiro UM, 2022. Fishermen's knowledge and conservation attitudes: focus on the Great Cormorant *Phalacrocorax carbo* (Linnaeus, 1758) in the Minho River, Portugal. *Aquat Ecol* 56:667-684.
- Villar DA, Thomsen B, Paca-Condori AC, Gutiérrez Tito ER, Velásquez-Noriega P, Mamani E, et al., 2024. Indigenous-wildlife conflict and coexistence in the Altiplano. *J Ethnobiol* 44:141-154.
- Wickham H, 2016. Data analysis, p. 189-201. In: *ggplot2: elegant graphics for data analysis*. Cham, Springer.
- Zumpano F, Copello S, Cabral V, Favero M, García G, 2024. Interaction between coastal birds and recreational fisheries in Argentina: incorporating the social dimension to improve effectiveness of conservation and management measures in a key estuarine reserve. *Mar Policy* 167:106278.

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Survey on Fishing Practices and Perceptions of the Great Cormorant (*Phalacrocorax carbo*) at Beni Haroun Dam, Algeria.

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