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First registration and description of the breeding biology of the Great cormorant *Phalacrocorax carbo* (Linnaeus, 1758) in the Fergana Valley of Uzbekistan

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Abstract

This study provides information on the discovery and preliminary ecological assessment of a new nest colony of the Great cormorant *Phalacrocorax carbo* (Linnaeus, 1758) in the Uzbek part of the Fergana Valley. Field studies conducted during the 2024 breeding season revealed the presence of nest colonies on two islands along the Syr Darya River. However, due to the existence of a border regime, the main work was carried out on the same island. In the study area, nests were found on 54 trees. Nests are mainly located in the poplar tree (*Populus pruinosa* Schrenk). Conducting monitoring using direct observations and camera traps, we recorded the nest occupancy, morphometric indicators of eggs, and the growth dynamics of chicks. The results show that the morphometric characteristics of great cormorant eggs can vary significantly depending on regional and ecological conditions. The chicks' weight increased rapidly from the moment they hatched until they flew away, although some deaths were also observed. Spatial analysis showed the expansion of colonies and the accumulation of nests, which indicates the successful settlement of the species in the region. These results provide important initial data on the ecology of the reproduction of the Great cormorant in Central Asia, emphasize the species' adaptability to local habitats, and indicate the need for continuous observations to develop conservation measures.

Keywords

Great cormorant, nest colony, stages of colony formation, nest biology, chick growth stages

Introduction

The Great cormorant is a bird whose entire life is closely connected with water bodies, and for its survival and reproduction, the presence of fish-rich, clean, and ecologically stable water bodies is of great importance. During the breeding period, colonies choose areas with trees and shrubs, reed beds, open sandy islands, and rocky areas along riverbanks (Shernazarov 2007). This species is found in various biotopes and many water bodies of Central Asia. Its population is adapted to various natural conditions. In Kyrgyzstan, they mainly lived in the Issyk-Kul region, Sonkol, and Lake Sarychelak (Kovshar 2019). In Kazakhstan, the main habitats are the Caspian Sea region, the shores of Lake Balkhash and the Irtysh River, the Aral Sea, the lower reaches of the Syr Darya, and the Chordara Reservoir during the winter season (Kovshar et al. 2012). In Tajikistan, natural water bodies such as Lake Bulun, Green Lake, Black Lake, and Lake Iskandar are important as habitats. One of the main places where birds gather during the winter period is the Kayrakum reservoir. These areas provide a feeding ground for the Great cormorant (Abdusalyamov 1971).

In Uzbekistan, the Great cormorant is a nesting, migratory, and rarely overwintering species (Sagitov 1987). Until the end of the 19th and the first half of the 20th century, the main nesting grounds were the shores of the southern Aral Sea region and the lakes of the Amu Darya delta. By the second half of the 20th century, new nesting colonies were found in the lakes Aydarkul, Tuzkon, Dengizkul, Karakir, Joldirbas, and along the banks of the Alan River (Kenzhegulov 1964a, 1965b). Many researchers have carried out extensive work on the nest colony of the Great cormorant in some regions of the country. According to Bogdanov (1882), the bird nests in the lower reaches of the Amu Darya, in its delta, and along the seashore. According to Zarudny (1916), the bird builds nests on the southern, western, and eastern shores of the Aral Sea, in the lower reaches of the Amu Darya. According to Gladkov (1935a, 1949b), it breeds on the Komsomol and Tokmak-Ata islands, near Muynak, at the confluence of the Kartabay tributary, and on Sudoche Island. In addition, it is noted that the number of populations is increasing in the reservoirs of the Bukhara region, in the lakes of the Amu Darya delta – Shamkekul, Kara-Khojabag and several nearby lakes, on the southern and eastern shores of the Aral Sea (Maslov 1947; Kostin 1956; Kenzhegulov 1965).

Subsequently, an increase in the number of populations was observed in the Aydar-Arnasay lake system. In particular, according to the results of studies conducted in 1981–1983 by Mukhina and Minaev (1983), as well as Shernazarov et al. (1985), on small islands of Lake Tuzkon in the Aydar and Tuzkon lakes located on the outskirts of Southeast Kyzylkum, the birds consistently used the same nesting area for several years. Although the first research work on the study of the animal world of the Fergana Valley began in the first half of the 19th century, information on the domestication of this species is not provided (Fedchenko 1875; Severtsow 1880; Stolzmann 1898; Kashkarov 1927; Salikhbaev 1956; Abdusalyamov 1971; Sharipov 1974). However, Kashkarov (1927) in his research recorded a small number of nesting cases in Lake Sarychelak, located in one of the mountainous regions of Kyrgyzstan.

Until now, nest colonies of the great cormorant have been identified in Uzbekistan mainly in the western regions of the republic, and the available data are limited to these territories. From this point of view, the discovery of a new colony in the Fergana Valley indicates the spread of this species in the eastern direction. This finding creates an important scientific basis for a deeper understanding of the current state of the Great cormorant population, as well as for analyzing the dynamics of their distribution and determining their economic significance.

The main goal of our research is to determine the stages of formation of a new colony, the effectiveness of nesting during the breeding season, to correctly assess the ecological and physical characteristics of natural habitats, as well as the degree of influence of anthropogenic factors on the colony.

Materials and methods

Study area

The Fergana Valley is located in the eastern part of Uzbekistan between the Alay and Tien Shan mountain ranges and is almost surrounded by high mountain ranges. From the south, it is surrounded by the Turkestan and Alay mountain ranges, from the east by Fergana, from the north by Chatkal, and the northwest by the Kurama and Karamazar mountain ranges. In the western part, through a narrow (8-9 km) "Khujand" gate, it connects with the Dalverzin and Mirzachul plains (Baratov 1996; Baratov et al. 2002). The length of the valley is 475 km from west to east and 260 km from north to south. The total length of the Fergana Valley border is more than 2000 km. The valley is located on the territory of 3 states. It accounts for 23% of the Republic of Uzbekistan, 68% for the Kyrgyz Republic, and 9% for the Republic of Tajikistan (Tobirov 2022).

Our research was conducted on a small island in the upper reaches of the Syr Darya River (Fig. 1). The Aral Sea is located on the left bank of the Syr Darya, on the border with Uzbekistan and Tajikistan. The area provides a suitable nesting environment for the colony and is located in an area with minimal wild and anthropogenic impact. The area was part of the Abdusamat State Forestry. The forestry area is 2158 hectares, of which 1459 hectares are covered by forests (An et al. 1980). The dendrological basis of the island consists of two tree species – turanga and oleaster (*Elaeagnus angustifolia* L), and a small number of various herbaceous plants. These trees have a suitable crown and sufficient height for birds to nest.

The climate of the Fergana Valley is continental. All this depends on its geographical location. The main winds enter the valley through the "Khojand" gate. Based on climatic characteristics, it is divided into northern, eastern, and southern parts. Spring is usually short and frequently changeable. The highest amount of precipitation is observed in this season. The summer is hot and long. The average temperature is +26°C, +27°C, the highest +40°C, +42°C. Warm weather is observed in the first months of the autumn season. In the second half of autumn, a sharp temperature change is observed (Hasanov et al. 2010).

Field surveys

The presence of bird nests on 54 turanga trees on the island was selected based on visual observation. Information was collected on the presence, number, and location of the nest on each tree. Due to border regime control, the island was visited on approved days of the week between 8:00 AM and 5:00 PM. Observations covered the period from mid-April to the end of July. The total number of visits was 8.

During the research, we used several observation devices. In particular, the SWAROVSKI SLS (15x56) binoculars for long-range observation of the colony, the SWAROVSKI ATX (30-70x95) observation tube, the Garmin GPS navigator for obtaining location coordinates and the Locus Pro mobile application, and the Nikon CoolPix P1000 camera for photographing biotopes and birds were used.

Camera trap monitoring

Monitoring of camera traps was used in our research as an important tool for observing the process of bird nesting and development. Bushnell and Viking AF cameras were used in the research. The cameras were mainly installed on tree branches at a distance of 1–1.5 m from the houses, through which information was collected about the behavior of chicks in natural conditions. The installation of cameras was developed by the appearance of nests and trees, which made it possible to obtain optimal images and videos. The observation period lasted from May 9 to May 23. When recording data, the interval between images was set to 1 minute for capturing the process in the nest, and the video recording time was set to 3 minutes. For complete storage of the collected data, a flash drive with a capacity of 128 GB was used. All devices are equipped with 12 AA Energizer Ultimate Lithium batteries. The functioning of the device and the state of memory were subjected to technical inspection during each visit.

To systematically analyze the daily life activity of birds in the natural environment, photo traps of 2 different brands were used alternately in the Q2 nest. Due to the introduction of a border regime in this territory, certain restrictions have been established for certain movements, and the processes of entry and exit, movement, and activities in the territory for a certain period have been strictly regulated and carried out based on temporary permits. Photo traps were installed as follows: from May 9 to May 21, 2024, Bushnell (BLL) brand photo traps, from May 21 to May 23, 2024, Viking AF (VAF) brand photo traps. During the camera installation process, the parent birds left the nest and returned to the nest approximately 30 minutes after installation. The photo traps were firmly attached to a strong tree branch on the opposite side of the nest, at a distance that did not directly disturb the birds, and to obtain high-quality photos and video images on a wide front. This approach was implemented in order not to affect the natural movements of birds while preserving the quality of the image and vision (Fig. 6). The visual data obtained from the installed camera trap were downloaded into the software operating on the special Windows operating system and systematically analyzed. The monitoring period was 14 days, during which more than 7,000 photographs and videos were recorded. Each visual information was considered separately, and the biological, ecological, and ethological processes reflected in them were deeply analyzed.

Measurements

To determine the size of the eggs and the weight of the chicks, an electronic caliper (accuracy 0.01 mm) and electronic scales (accuracy 0.01 g) were used. The volume of the egg was calculated according to the formula of Romanov and Romanova (1959), modified by Hoyt (1979): $V=0.51xLxB^2$, where: V – egg volume (mm^3), L – length (mm), B – width (mm). It should be noted that all measured eggs were carried out during the incubation period. As a result, a decrease in initial weight by 10–20% can be observed. The shape index (%) was calculated according to the formula S_{ph} =100xB/L (Myand 1988). The Lakin (1973) method was used to calculate the main morphometric indicators of the eggs. In this case, the average statistical value (M), average error (m), standard deviation (σ), and coefficient of variation (CV) were calculated. Average differences were implemented in the PAST 4.0 software. Taking into account all the limitations, our study covered the breeding period of birds in only one season. Obtaining nest parameters was carried out according to the Mikheev (1975) method.

Due to the border regime applied in the area, practical location restrictions, and the fact that birdhouses are located at the top of upright trees, it is possible to observe all chicks according to the established schedule. Therefore, the chickens' weight was measured at available times, i.e., during visits, using the opportunistic sampling method. Assessment of nest status was carried out according to the Standardized Nest Status Classification Protocol (Simon and Pacheco 2005), where the presence of eggs, parental involvement, and nest status were taken as the main criteria.

Data analysis

ArcGIS Pro 3.1.0 was used to create maps of the studied territories. The physical dimensions of the territory occupied by the colony have been determined. For this purpose, remote sensing was conducted over the years through the historical image display section of the Google Earth Pro (GEP) program. During the study, walking along the contours of the colony was carried out, and a GPS track was recorded using the Locus Map mobile application. This track was saved in KMZ format and subsequently exported to GEP. Using the capabilities of the program, the external boundaries of the colony were clearly defined, and an analysis of the area and shape was carried out. This approach made it possible to accurately assess the real state of the terrain from a spatial point of view.

Results

On April 19, 2024, for the first time in this area, 2 nest colonies of the great cormorant were identified (Umarov 2024). The colonies are located on two large islands of the Syr Darya River (Fig. 1). The research area is located on the border with Uzbekistan and Tajikistan and is a protected area.

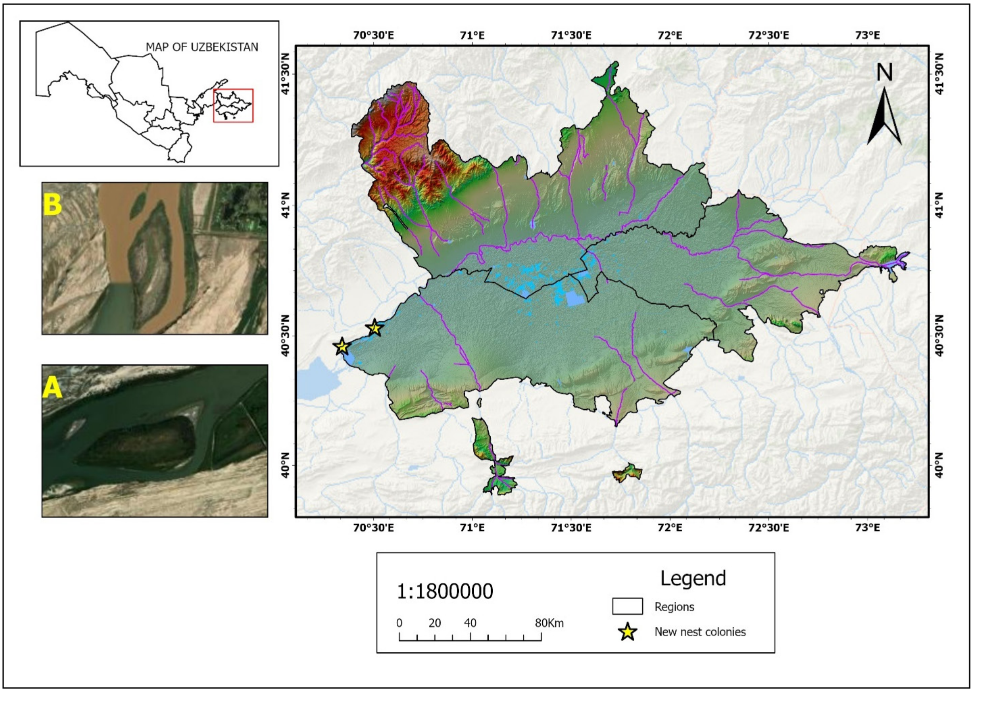

Figure 1. Map of islands where a colony of *P. carbo* was found.

According to scientific literature, the main colonies of the great cormorant were first recorded in the water bodies of the western part of the republic (Sagitov 1987). In the first half of the 20th century, this species nested in Lake Sarichelak, located in the territory of Kyrgyzstan in the Fergana Valley. In the summer of 1925, Kashkarov (1927) identified two colonies consisting of 4-6 nests in dry birch trees located above the water. Subsequently, according to Lebyazhina (1991), starting from 1982, anthropogenic factors led to the disappearance of bird nests in this area.

Colony size and nest distribution

Birds in the colony used turanga to build nests. The average diameter of the trees was 62.2 cm (n=54, lim=18–97 cm).

In European countries, Great cormorants often use various artificial structures as nesting sites when natural nesting sites are not available. For example, they choose places with dams, lighthouses, power lines, abandoned ships, and old metal structures. All these places create favorable conditions for their safety and nest building (Santoul et al. 2004; Vizi 2014; Tertitski 2014; Szinai 2014; Sidorenko and Siokhin 2016).

Nests found in Uzbekistan are mainly found in tamarisk (*Tamarix ramosissima* Ledeb.) on Dengizkul, common reed (*Phragmites australis* (Cav.) Trin. ex Steud.), in the first year of nesting in Aydarkul bushes of turanga and tamarisk, later, as a result of the growth of the colony, cases of nesting on the ground were observed (Shernazarov 1992).

All nests in the study area are located differently on the trees: next to the tree trunk, on the crown, and the edges of the branches. In the studied 54 trees, there are nests of the Great cormorant, Black-crowned Night Heron *Nycticorax nycticorax nycticorax* (Linnaeus, 1758), the Grey Heron Ardea cinerea Linnaeus, 1758, and in the vicinity of the colony, on 7 trees located at different distances, the domestic populations of the white stork *Ciconia ciconia asiatica* Severtzov, 1873 were identified. As a result of visual observation, a great cormorant nest was registered mainly on 36 trees. The number of nests was determined to be 1-8, depending on the branching and location of the tree (Figs 2, 3).

Great cormorants use the materials available around the nest in the process of building it. For example, dry reeds, saxaul branches, and sometimes bird feathers can be used (Kenzhegulov 1964). According to Minaev's research (1983), the height of nests in tamarisk trees is 30–100 cm (average 55 cm), the outer diameter reaches 50-65 cm, and the building material consists of tamarisk branches and twigs, and in some cases, bird feathers along with reed stems.

Dry turanga branches and various small tree branches were used around the inspected nests. The interior of the nest consists of reed leaves, stems, and rhizomes. At the same time, the presence of various artificial materials, including paper, polyethylene, and foam plastic, imported from water bodies with a high level of pollution, was observed.

When analyzing the distribution of the number of nests by trees, it was noted that the nest distribution within the colony was significantly uneven. According to official estimates, the most common case of 4-node nests was recorded on 11 trees and constituted 30.5% of the total number of samples. This indicates that the main units reflecting the optimal density within the colony are precisely 4 cellular trees. In slightly fewer trees, 2 nests (6 trees, 16.7%) and 5 and 6 nests (5 trees each, 13.4%) were found. This indicates that medium-density trees are also widespread in the colony. It should be noted that the trees with 5 and 6 nests are relatively large, with broad branches or a strong structure, which indicates the availability of conditions for nesting by birds. Trees with only one nest were very rare (only 2.88%), which can be explained by the fact that such trees are not required in the colony, or there are not enough branches for building a nest. In addition, up to 7–8 nests were identified in the near-water part of the trees (11.1%). This situation shows that important factors for birds in tree selection are related to height, degree of branching, tree placement, and safety.

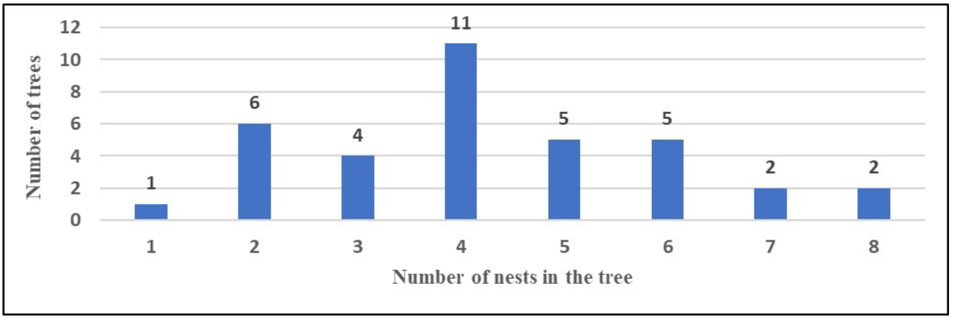

Figure 2. Quantitative distribution of nests by trees in the *P. carbo* colony (n=36 trees).

Figure 3. Overview of high-density nests in the waterside part of the colony and colonies in one part of the island, May 2024. Photo by S.S. Umarov.

Egg morphometrics

The great cormorant is considered an early-breeding species. On March 14, 1981, the first egg laying was observed on Lake Tuzkon (Minayev 1963). The birds began laying eggs on March 6–7, 1983, and February 26–27, 1989 (Shernazarov and Mirsalikhova 1990). However, in 1990, the winter reproduction of this species was recorded for the first time in Lake Aydarkul in Central Uzbekistan (Shernazarov 2015).

The results of scientific research confirm that the reproduction, growth, and development of chicks within one colony occur at different stages. The dynamics of these processes are inextricably linked with the ecological state of the territory, are formed under the influence of abiotic and biotic factors, and directly affect the life strategy of the population.

During the expedition to the island on April 19, 2024, it was observed that all Great cormorants had occupied their nests and laid eggs. Due to the high placement of the nests (on average 3–10 m), it was difficult to climb them. In addition, the smoothness of the trunks of all the trees also made it difficult to approach the nests. However, a total of 5 trees were examined, where a large elm nest was located and where it was possible to emerge, and the external dimensions of the nest were 42–48 cm, the tray diameter 28–35 cm, the nest height 25–30 cm, and the nest depth 3–6 cm. Up to 4–6 nests were identified on each tree. The nests were mastered by *N. nycticorax* and *P. carbo*. In some trees, a single species was observed, which indicates the presence of ecological specialization. Each of the cells was assigned special numbers (A1–E3). The number of eggs was recorded for each nest. In some nests, there were 3–4 eggs. Empty nests (A2, B4) were designated as nests that have not yet laid eggs (Table 1).

Table 1. Number of trees examined

Trees examined	Tree's diameter (Lim) cm	Total nests	Black-crowned Night Heron's nest	Great Cormorant's nests		Number of eggs
1	33–96	4	2	2	A1	3
					A2	0
2		4	Do not exist	4	B1	3
					B2	4
					B3	3
					B4	0
3		4	3	1	C1	2
4		4	2	2	D1	4
					D2	4
5		6	3	3	E1	3
					E2	3
					E3	2

Note: A1–E3 nest number, 0 – empty nest.

In total, the main morphometric indicators of 31 eggs were obtained from 10 nests. Measurements were carried out according to the weight (g), length (mm), width (mm), volume (mm^3), and shape index (%). For each parameter, the minimum and maximum values, average value and average error, coefficient of variability, and standard deviation were calculated (Table 2).

Table 2. Morphometric indicators of Great Cormorant's eggs (n=31)

Indicators	Lim	M±m	CV%	SD
Weight (g)	47.1–51.9	48.9±0.25	2.83	1.38
Length (mm)	60.9–63.0	62.1±0.09	0.81	0.50
Width (mm)	37.9–39.9	39.1±0.10	1.38	0.54
Volume (cm^3)	44.6–51.12	48.4±0.24	2.76	1.33
Form index (%)	60.83–65.14	62.94±0.19	1.67	1.05

Note: Lim – minimum and maximum indicators, M±m – mean value and standard error, CV% – coefficient of variation, SD – standard deviation.

According to our research results, the average size of the eggs obtained with morphometric indicators (n=31) was 62.1 x 39.1 mm, and the average weight was 48.9 grams. The average egg volume was 48.4 cm^3. The shape index averaged 62.94%. This index is characterized by the length and width of the egg.

As a result of scientific research conducted in various regions of the country, important data on the morphometric indicators of great black-headed gull eggs were recorded. According to Kenjugulov (1964), in the Amu Darya region and the Aral Sea area, the average size of the eggs of this species (n=3) was 63.3 x 39.6 mm, and their average weight was 52.306 g. In studies conducted on Lake Tuzkon, Minaev (1983) noted that during the secondary breeding period, a great black-headed gull lays from 1 to 5 eggs in one nest. The morphometric dimensions of the eggs were 55.9–64.3 x 38.2–41.5 mm, and the average size was 60.8 x 39.8 mm. In the southeastern Kyzylkum region, Shernazarov et al. (1985) reported that the average size of great black-headed gull eggs (n=233) was 61.9x39.8 mm, the minimum size was 52.1x36.1 mm, and the maximum size was 70.8 x 44.9 mm. These results show that the morphometric characteristics of great black-headed gull eggs can differ significantly depending on regional and ecological conditions.

Chick growth

To correctly assess the nest condition, two nests (Q1, Q2) were selected and observed from the nests in 5 trees that were initially examined. In one of them, three chicks of different ages (N1-N3) were found. The smallest of these chicks, according to morphometric indicators, was approximately two weeks old. On another branch of the tree, three eggs were found (Q2). According to Sagitov (1987), the great black-headed gull incubates the eggs for 28–30 days, completing the incubation process. Based on this scientific evidence, it can be assumed that the eggs found were laid approximately on March 29–31, and according to the developmental stage of the chicks, the egg-laying process began on March 22–24. During the observation, the weight of the three chicks was measured, and their legs were marked with a special string. When collecting oological material, attention was paid to measures not to disrupt the natural reproduction process of birds and not to disturb other nests, and due to the strictness of the existing border regime, the weight dynamics of the chicks were recorded at certain times (Fig. 4).

A total of six nest inspection visits were carried out in the Aral Sea region. During the initial visit, a proportional weight gain was observed in all chicks in the Q1 nest. Of these, chick N3 was weighing more than the other two chicks. This can probably be explained by the fact that it emerged earlier and more effectively absorbed the feed brought by its parents. During the second visit, the weight of the chicks in the Q1 nest was re-measured. At the same time, in the Q2 nest, only two chicks (S1 and S2) hatched. The chick in the third egg (S3) was found freshly hatched, dead under the nest. It should be noted that a small number of Eastern Carrion Crow *Corvus corone orientalis* (Eversmann, 1841), have been recorded nesting on the island. Previous visual observations noted that representatives of this species showed aggressive behavior towards other birds in the colony. Based on this, it is possible that the death of the S3 chick was directly related to the attack of the Carrion crow.

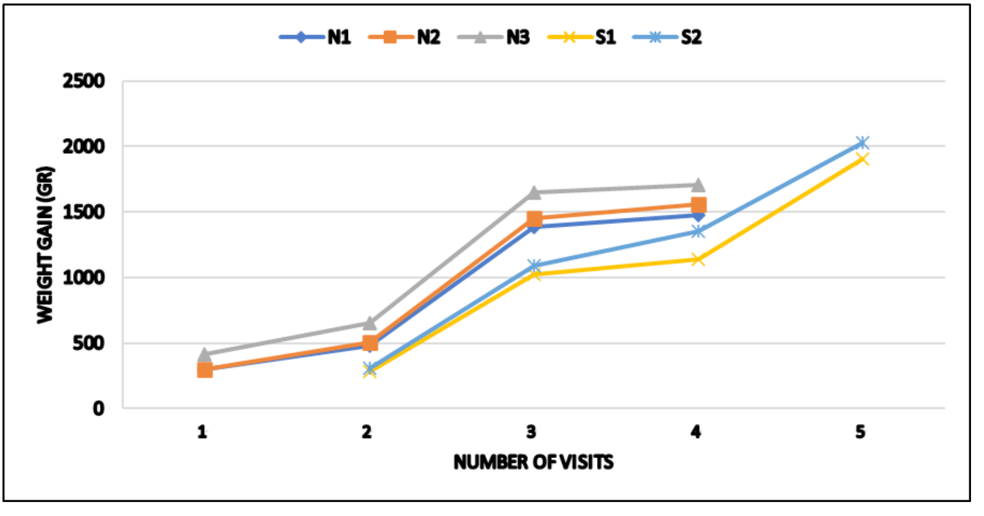

Figure 4. Increase in the weight of the Great Cormorant's chicks.

The dynamics of weight gain of chicks in Q1 and Q2 nests were compared. Based on the data in the table, it can be said that the weight gain of chicks S1 and S2 in nest Q2 was higher than that of chicks in nest Q1. This difference is probably because there are only two chicks in the Q2 nest. Since the food brought by the parents was distributed among fewer individuals, it can be said that each chick consumed more food, which contributed to their faster growth. The chicks in the Q1 nest had already flown out of the nest during the inspection on 01.06.24. Since the two chicks that remained in the Q2 nest laid their eggs relatively late, they left the nest on 10.06.24 (Fig. 5).

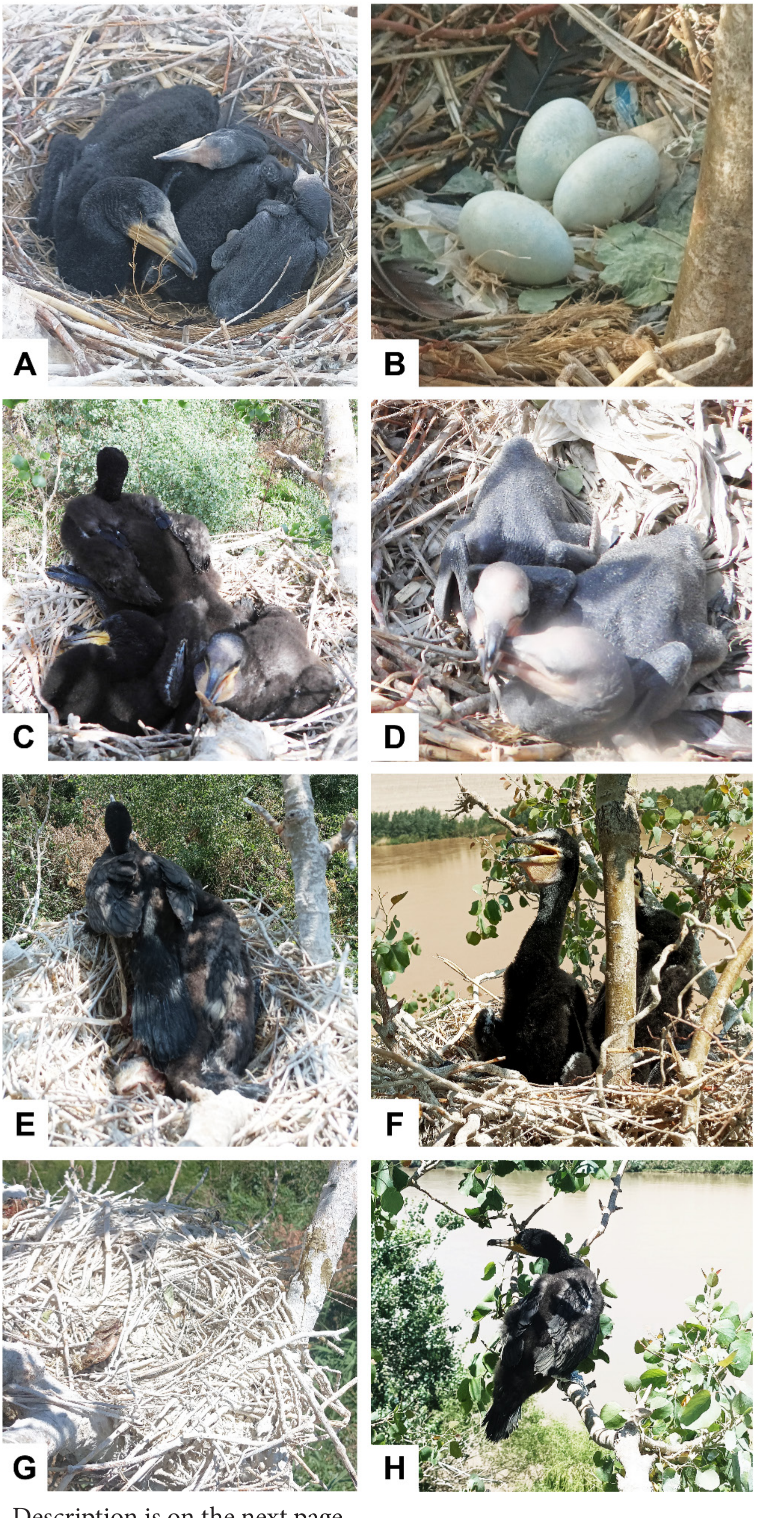

Figure 5. Description is on the next page.

Figure 5. The state of development of *P. carbo* eggs and chicks in nests Q1 and Q2 at different stages (27.04.–1.06.24): **A** – 2-week old chicks; **B** – Incubation period; **C** – 4-week-old chicks; **D** – 2-week old chicks; **E** – chicks 6 weeks old; **F** – 4-week-old chicks; **G** – left the nest; **H** – 6-week-old chicks.

These images were photographed and analyzed during direct personal observations. Chicks in the Q1 nest (Fig. 5A) were located in the eastern part of the tree and had different levels of development. All chicks showed a noticeable reaction only to the feed brought by their parents, and a weak reaction to the external environment. The chicks in Fig. 5C are approximately 4 weeks old, and at this stage, their feed requirements are high. At the same time, an intensification of the response to external stimuli was observed. The chicks shown in Fig. 5E are approximately 6 weeks old and quite mature. Full feathers began to form on their body covering, indicating a preparatory stage for flight. During the next visit, it was found that the chicks left the nest at the age of 9 weeks. Depending on the condition of the food remnants remaining inside the house, they may have been brought in 1–2 days ago, which indicates that the process of leaving the nest occurred recently.

The Q2 nest is close to the water and is located along the shore. In total, 3 eggs were found in the nest during the incubation period. During the inspection on May 9, 2 hatching chicks were found in the nest. The remaining chick was found dead under a tree. The growth of two chicks relative to the Q1 nest changed intensively. Due to the abundance of food and the absence of other birds in the nest, it grew quickly. 6-week-old chicks (Fig. 5H) defended themselves and exhibited a strong response to external stimuli. Judging by its behavior, it can be seen that it tightly grips tree branches with its paws and soon leaves the nest, seeing the development of flight feathers. Such behavior is typical for Great cormorant chicks and is one of the important stages in the process of transitioning to independent flight. Existing nests on 36 trees studied that day were checked. The calculation was performed by climbing a lower tree or using a telephone camera attached to the end of a special rod 6 m long. As a result, it was found that 97.2% of the trees in the houses had 3-5 2-4-week 4-week-old chicks, while the remaining 2.8% of the nests had some incubation processes and some were empty.

According to scientific literature, including Dementev and Gladkov (1951), adult Great cormorant chicks begin to develop the ability to fly at approximately 7 weeks of age. At this stage, they begin exercising frequently to strengthen their wing muscles, maintaining balance on the branches, and flapping their wings for short distances. In addition, chicks can leave the nest at 8 weeks of age. In some cases, they abandon the nest and try to swim and dive in the water even when they are not yet fully capable of flying.

According to Kenjegulov (1964), as of June 26, almost 50% of chicks in the nests in the Kazakh River (northern Uzbekistan) have already flown away. On May 20, 1983, in the colony on Lake Tuzkon (central Uzbekistan), the mass flight of young birds from their nests ended by June 10 (Minayev 1983). Our observations showed that on July 26, only the chicks of the magpie and the gray crow, ready for flight, remained on the island. All the Great cormorants had left the nest.

Analysis of camera trap data

Existing video and photo data were systematically analyzed (Fig. 6). According to the analysis results, the birds did not have a significant impact on their natural behavior. In particular, it was observed that the infrared radiation emitted by the devices in the evening did not cause changes in anxiety or activity in the birds. In the early stages, since the chicks were young, the parents spent most of their time in the nest with their chicks. By pressing them with the body in a warm state, they maintained a stable temperature. During this period, the delivery of feed was carried out by alternating actions of the father and mother.

Also, the birds brought food to the chicks from the water-facing part of the nest, flying from a height of about 50–60 meters. Food was delivered to the nest from the open side, and the birds flew back to the diomo at a distance of 0.5–1 meters from the water level. After a certain period, from approximately the 2nd week, the chicks' bodies were covered with thick hairs, and flight and control feathers began to form. By the 3rd week of development, the formation of shoulder feathers, fan wings, covering feathers, and tail feathers began to be observed in the chicks. It has become natural for parent birds to make loud sounds, especially screams, when approaching the nest. Chicks that have reached the age of 24–25 days have developed their ability to move, crawling on tree branches, clinging to tree branches with their paws, and maintaining balance using their neck and beak.

Observations showed that the activity of the chicks in the inner zone of the nest increased. Based on the analysis of video recordings and photographs, the feeding dynamics of chicks were also studied. According to observations, the feeding of chicks by parents was carried out mainly up to three times a day, initially with a feeding frequency of up to 2 times, then with increasing weight and increasing feed requirements, the daily regime changed up to 5 times. Video footage shows that on some days, the delivery of feed was carried out even at midnight. Observations conducted based on the obtained records showed that the parent birds act alternately in feeding the chicks and ensuring the safety of the nest. That is, they take an active part in raising their offspring by taking turns bringing food and standing on duty near the nest. This indicates a high degree of behavioral or instinctive development among birds.

Figure 6. Results of BLL and VAF camera traps (09.05–23.05.2024).

Spatial analysis

A spatial analysis was conducted on the expansion of the colony. The distance and total area of the island's terrestrial geometric shape were calculated using the GEP. In this case, it can be seen that the formation of the nest began in 2012, within 10–12 years, the colony was formed, and their number gradually increased. The first satellite image showed that the main part of the colony is located on the riverbank in the form of two subcolonies (Fig. 7). These figures indicate that the base of the colony is expanding from the coastline.

By 2023, one colony had expanded more intensively than the other, forming the main colony. According to the results of the exported KMZ file, the total area of the main colony was 6582 m^2, while the remaining subcolony was 118 m^2. Great cormorants' nests are mainly located by the water, and it can be seen that this selection is ecologically adapted due to proximity to the food base and relative protection from predators. It was also revealed that the dense arrangement of nests occurred mainly in the northeastern direction, as can be seen from the results of spatial analysis (Fig. 8).

Figure 7. Initial coastal location of the colony (2012).

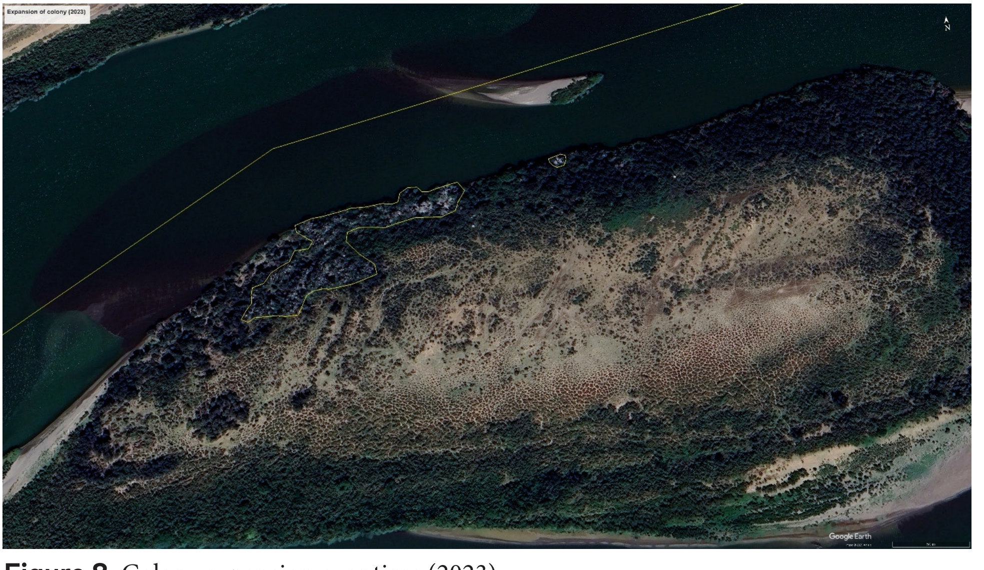

Figure 8. Colony expansion over time (2023).

The expansion of the colony can be assessed by the increase in the number of artificially created fish farming ponds along the Syrdarya River and changes in fish diversity. The change in newly developed lakes from 2012 to 2024 was analyzed using the GEP. In the calculation, the number of artificially created lakes from the state border to two islands along the left bank of the river was calculated in hectares (ha). In 2012, there were a total of 998 hectares of lakes, and by 2024, their area had reached 1,568 hectares. Today, this indicator has increased by 1.57 times. According to our observations and information received from fishermen, the main fish species are the white amur (*Ctenopharyngodon idella*), carp (*Cyprinus carpio*), snakehead (*Channa argus warpachowskii*), and silver carp (*Hypophthalmichthys molitrix*).

Discussion

The formation of a new colony of great cormorant in the Fergana Valley over the past decade confirms the tendency of the species' expansion from west to east in the territory of the republic. This shift is likely explained by the improvement of ecological conditions in the eastern regions, in particular, the emergence of suitable habitats for nesting and feeding. The presence of sufficient fish stocks in the territory contributed to the establishment of bird populations and the expansion of the colony's territory. These factors indicate the ecological adaptability of the Great cormorant.

According to the research results, a sufficient number of nests in the colony significantly reduced the level of internal competition. As a result, there was no intensive struggle for resources, in particular, nesting sites and food, which led to the absence of cases of repeated laying of eggs. Also, the fact that this colony is located in a restricted territory, that is, limited human intervention, served as a factor ensuring security. As a result, 97% of the colony's chicks successfully matured and were able to fly independently. This indicator led to an increase in high reproduction efficiency for the Great cormorant population.

In other regions of the republic, various factors contributed to the successful maturation of chicks. For example, most nests are located in fishing ponds. People disturbing the nest, ruthless egg collection, direct sunlight on eggs laid in open areas, eating chicks, and other effects had a direct impact. Strong winds or rising water levels washed away nests near the shore. In some areas, Carrion Crow have caused some damage to the colony (Shernazarov 2007).

The impact of the proliferation of the Great cormorant in all European countries on the fishing industry has been assessed. According to calculations conducted by the International Wetlands Organization in the summer of 2006, the number of Great cormorants that laid eggs in the western Palearctic is 744,672 and causing significant damage to fisheries (Shwiff et al. 2015; Steffens 2010).

Tugai forests are dense thickets along rivers. Due to its good water supply and relatively humid and mild microclimate, a unique flora and fauna have formed in this area (National Encyclopedia of Uzbekistan 2002). The presence of such conditions created the basis for the growth of Great cormorant colonies. In particular, the fact that the island on which the colony was located was surrounded by water on both sides served as a means of natural protection of this territory. This geographical location restricted the free entry of predatory mammals and other dangerous animals into the colony. This ensured the safety of eggs and chicks and served to increase the success of breeding. In addition, one of the important factors can be considered the limited human activity in this area. The absence of human interference created a peaceful and safe breeding environment for this species. Under these conditions, members of the colony were able to mate more often, raise more chicks, and increase the total population size.

In areas with dense colonies, vegetation cover and especially large trees are severely damaged. Large amounts of bird droppings lead to a high accumulation of chemical elements such as nitrogen, potassium, and phosphorus in these areas. The ichthyophagy of the species further intensifies this process, as the high content of minerals in fish is released back into the environment through bird feces. As a result of the excessive accumulation of these substances, the chemical composition of the soil changes, acquires an acidic character, and this condition negatively affects the normal functioning of tree roots. As a result, trees lose their balance during the nutrition process, photosynthesis slows down, and they dry up over time. The drying of trees leads not only to the depletion of vegetation cover but also to the loss of habitat for other animal species (Fig. 9).

Scientific research conducted in European countries also confirms the biological characteristics of this species, in particular, the degradation of vegetation cover as a result of nesting in dense colonies and the release of a large amount of feces. This process leads to negative consequences, especially for trees and dwarf plants. It also contributes to a decrease in the number of nesting bird species in the colony (Elizabeth 2012; Hebert et al. 2014; Matulevičiūtė et al. 2018; Sydorenko 2023).

The fact that the colony is located on the border of the two countries – Uzbekistan and the neighboring country- the problems with entering and exiting the territory, as well as the difficulties in collecting biological samples, made it difficult to fully assess the state of the Great cormorant population. In particular, the fate of private fish farming lakes in inland water bodies located near the colony remains unknown. The feeding habits of Great cormorants can lead to economic losses in these basins, which leads to an increase in social objections to problems related to the state of the population. Therefore, it is important to assess the long-term dynamics of the population, the ecological and economic consequences of the expansion of the colony.

Thus, this study not only reveals the specific features of the ornithofauna but also covers deeper aspects, such as the state of the environment, the prospects for negative changes in biotopes, and the resulting social and economic problems. In general, highlighting the unexplored aspects of the regional ornithofauna creates an important basis for future scientific research. Especially in the foothill zones and valley territories of Central Asia, it serves as the main guide in determining new directions for monitoring, protection, and management of poorly studied ornithofauna species.

Figure 9. Trees were damaged by the colony.

Conclusions

The newly discovered Great cormorant colony in the Fergana Valley is an important addition to the known reproductive populations in Uzbekistan. Our research shows that this species effectively uses riverbank tree species for nesting and exhibits typical reproduction rates characteristic of other Eurasian colonies. The combination of field observations and camera trap monitoring provided detailed information on nest placement, egg characteristics, and chick development during the 2024 breeding season. Although the colony appears to be stable and expanding, the limited timeframe of this study emphasizes the importance of long-term observation to identify interannual variability and potential environmental hazards. Future research should focus on extensive territorial coverage, long-term data collection, and human impact assessment to support effective conservation for this species in the region.

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References

Abdusalyamov IA (1971) Fauna of Tajikistan. Volume 1. Birds. Dushanbe, 402 pp. [In Russian]

An ES, Botman KS, Goncharov VE, Dudura IM, Kulbashnaya LYa (1980) Protected Territories of Uzbekistan. Tashkent, 70 pp. [In Russian]

Baratov PB (1996) Natural Geography of Uzbekistan. Tashkent, 264 pp. [In Uzbek]

Baratov PB, Mamatkulov M, Rafikov A (2002) Natural Geography of Central Asia. Tashkent, 440 pp. [In Uzbek]

Bogdanov MN (1882) Essays on the Nature of the Khiva Oasis and the Kyzyl-Kum Desert. Tashkent, 155 pp. [In Russian]

Dementiev GP, Gladkov NA (1951) Birds of the Soviet Union. Volume 1. Soviet Science Publishing House, 642 pp. [In Russian]

Elizabeth CC, Susan BE, James AD, and Matthew IP (2012) Impacts of Double-Crested Cormorants (*Phalacrocorax auritus*) and Other Colonial Waterbirds on Plant and Arthropod Communities on Islands in an Urban Estuary. Waterbirds 35(sp1): 4–12. https://doi.org/10.1675/063.035.sp102

Fedchenko AP (1875) Journey to Turkestan. Volume 1. Moscow, 177 pp. [In Russian]

Gladkov NA (1935) New data on the distribution of birds in the Amu Darya delta. Bulletin of Samarkand State University 21: 83–91. [In Russian]

Gladkov NA (1949) Observations on the birds of Komsomolsky Island (Aral Sea). Nature Conservation 8: 29–43. [In Russian]

Hasanov IA, Gulomov PN, Qayumov AA (2010) Physical Geography of Uzbekistan (Part 2). Tashkent, 161 pp. [In Uzbek]

Hebert CE, Pasher J, Weseloh DVC, Dobbie T, Dobbyn S, Moore D, Minelga V, Duffe J (2014) Nesting cormorants and temporal changes in Island habitat. The Journal of Wildlife Management: 78: 307–313. https://doi.org/10.1002/jwmg.659

Hoyt DF (1979) Practical methods of estimating volume and fresh weight of bird eggs. The Auk 96(1): 73–77.

Kashkarov DN (1927) Results of the expedition of the Main Central Asian Museum to the area of Lake Sary-Chilek. Tashkent, 112 pp. [In Russian]

Kenzhegulov KK (1965) On the number and economic importance of Pelecaniformes birds in the lower reaches of the Amu Darya delta. Bulletin of the Karakalpak Branch of the Academy of Sciences of the Uzbek SSR 3(21): 49–51. [In Russian]

Kenzhegulov KK (1964) Ecology of the Great Cormorant in the Amu Darya Delta and the Aral Sea. Bulletin of the Karakalpak Branch of the Academy of Sciences of the Uzbek SSR 4(18): 55–60. [In Russian]

Kostin VP (1956) Notes on the avifauna of the left bank of the lower reaches of the Amu Darya and Ustyurt. Proceedings of the Institute of the Zoology and Parasitology Academy of Sciences of the Uzbek SSR 8: 81–127. [In Russian]

Kovshar AF (2019) Birds of the Tien Shan (Middle Asian part of the mountain system in the limits of Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan). Volume 1. Non-passerines. Almaty, 560 pp. [In Russian]

Kovshar AF, Berzovikov NN, Gistov AP, Yerokhov SN, Zhatkanbayev Azh, Kovshar VA (2012) Gaviiformes-Anseriformes. Fauna of Kazakhstan in 30 volumes. Vol. 2. Birds. Part 1. Almaty, 293 pp. In Russian]

Lakin GF (1973) Biometry. Higher School, Moscow, 343 pp. [In Russian]

Lebyazhina IP (1991) Structure and dynamics of the summer population of birds of the Sary-Chelek State Biosphere Reserve. Fauna and ecology of terrestrial vertebrates of Kyrgyzstan. Bishkek, 48–51. [In Russian]

Maslov NM (1947) Birds of the Bukhara region. Collection of scientific works of the Bukhara State Pedagogical Institute. Natural Science. Bukhara, 45–70. [In Russian]

Matulevičiūtė D, Motiejūnaitė J, Uogintas D, Taraškevičius R, Dagys M, Rašomavičius V (2018) Decline of a protected coastal pine forest under the impact of a colony of great cormorants and the rate of vegetation change under ornithogenic influence. Silva Fennica 52(2): 131–146. https://doi.org/10.14214/sf.7699

Mikheev AV (1975) Guide to Bird Nests. Moscow, 171 pp. [In Russian]

Minayev N (1983) Nesting of the Great Cormorant on Lake Tuzkan. Ecology of Plants and Animals in Uzbekistan's Nature Reserves. Tashkent, 61–65. [In Russian]

Mukhina EA (1983) Nesting near-water and waterfowl birds of the Arnasay Reserve. Ecology of plants and animals in Uzbekistan's Nature Reserves. Tashkent, 66–82. [In Russian]

Myand R (1988) Intrapopulation variability of avian eggs. Valgus, Tallin, 195 pp.

National Encyclopedia of Uzbekistan (2013) Tashkent, 856 pp.[In Uzbek]

Romanoff AL, Romanoff AJ (1949) The Avian Egg. Moscow, 550 pp. [In Russian]

Sagitov AK (1987) Birds of Uzbekistan. Volume I. Pelecaniformes. Tashkent, 291 pp. [In Russian]

Salikhbaev KhS (1956) Vertebrates of protective forest plantations of Uzbekistan. Proceedings of the Institute of Zoology and Parasitology Academy of Sciences of the Uzbek SSR 8: 129–193. [In Russian]

Santoul F, Segura G, Mastrorillo S (2004) Environmental determinants of Great Cormorant (*Phalacrocorax carbo*) distribution in small man-made waterbodies – a case study of gravel pits in southwest France. Hydrobiologia 528: 179–186.

Severtzow N (1880) Etudes sur le passage des oiseaux dans l'Asie centrale. Bulletin de la Société impériale des naturalistes de Moscou 55(2), 234 pp. [In Russian]

Sharipov M (1974) Ecology and importance of birds in the cities of the Fergana Valley. PhD Thesis, Institute of Zoology, Academy of Sciences of the Uzbek SSR, Tashkent. [In Russian]

Shernazarov ESh (2007) Order Pelicaniformes. Great Cormorant. The birds of middle Asia. Volume 1. Almaty, 574 pp. [In Russian]

Shernazarov ESh, Ostapenko MM, Lanovenko EN, Paramonov SE (1985) The number and some biological features of the Great Cormorant in the south-eastern Kyzylkum. Uzbek biological journal 1: 41–43. [In Russian]

Shwiff SA, Kirkpatrick KN, DeVault TL, Shwiff SS (2015) Modeling the economic impacts of double-crested cormorant damage to a recreational fishery. Human-Wildlife Interactions 9(1): 36–47.

Sidorenko AI, Siokhin VD (2016) Nesting of Great Cormorants (*Phalacrocorax carbo*) on man-made structures in Ukraine. Biosystems Diversity 24(2): 308–316. https://doi.org/10.15421/011640 [In Russian]

Simon JE, Pacheco S (2005) On the standardization of nest descriptions of Neotropical birds. Revista Brasileira de ornitologia 13(2): 143–154.

Steffens W (2010) Great cormorant–substantial danger to fish populations and fisheries in Europe. Bulgarian journal of agricultural science 16(3): 322–331.

Stolzmann J (1897) Oiseaux de la Ferghana. Bulletin de la Société impériale des naturalistes de Moscou 1: 54–81. [In Russian]

Sydorenko A (2023) Biocenotic influence of the great cormorant (*Phalacrocorax carbo* L.) in the Azov-Black Sea region of Ukraine. In IOP Conference Series: Earth and Environmental Science 1254(1): 012013.

Szinai P (2014) Status of the breeding population of Great cormorants in Hungary in 2013. In: Bregnballe T, Lynch J, Parz-Gollner R, Marion L, Volponi S, Paquet JY, Carss DN, van Eerden MR (Eds) Breeding numbers of Great cormorants *Phalacrocorax carbo* in the Western Palearctic, 2012–2013. IUCN-Wetlands International Cormorant Research Group Report. Scientific report from DCE – Danish Centre for Environment and Energy, Aarhus University (99): 121–125. http://dce2.au.dk/pub/SR99.pdf

Tertitski G, Cherenkov A, Semashko V (2014) Status of the breeding population of Great cormorants in the Onega Bay of the White Sea (Russia) in 2013. In: Bregnballe T, Lynch J, Parz-Gollner R, Marion L, Volponi S, Paquet JY, Carss DN, van Eerden MR (Eds) Breeding numbers of Great cormorants *Phalacrocorax carbo* in the Western Palearctic, 2012–2013. IUCN-Wetlands International Cormorant Research Group Report. Scientific report from DCE – Danish Centre for Environment and Energy, Aarhus University (99): 187–189. http://dce2.au.dk/pub/SR99.pdf

Tobirov O (2022) Methodology for Assessing the Tourist Potential of the Nature of the Fergana Valley using GIS Technologies and Experimental Methods. Preprint. https://doi.org/10.20944/preprints202209.0181.v1

Vizi A (2014) Status of the breeding population of Great cormorants in Montenegro in 2012. In: Bregnballe T, Lynch J, Parz-Gollner R, Marion L, Volponi S, Paquet JY, Carss DN, van Eerden MR (Eds) Breeding numbers of Great cormorants *Phalacrocorax carbo* in the Western Palearctic, 2012–2013. IUCN-Wetlands International Cormorant Research

Group Report. Scientific report from DCE – Danish Centre for Environment and Energy, Aarhus University (99): 143–145. http://dce2.au.dk/pub/SR99.pdf
Zarudny NA (1916) Birds of the Aral Sea. Proceedings of the Turkestan Department of Russian Geographical Society 12(1), 229 pp. [In Russian]