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REVIEW

Distribution and Status of the Pallas's Gull *Ichthyaetus ichthyaetus* (Pallas, 1773) in the Reservoirs of the Palearctic: Review

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ABSTRACT

The Pallas's Gull *Ichthyaetus ichthyaetus* is a piscivorous gull, some local populations of which are rare and vulnerable. The review presents data on the status and distribution of the Pallas's Gull in the reservoirs of the Palearctic—water bodies in which the water level is controlled by humans. The aim of the study was to assess the current state of the species in the reservoirs of the Palearctic. The review was based on 1080 publications found in the search engines Yandex, Google, Google Scholar, eLybrary. During the last 35 years, the Pallas's Gull has been found in 63 reservoirs of the Palearctic. Breeding has been established in 11 reservoirs, breeding has not been established in 43 reservoirs, and birds were present in 9 reservoirs, but the status was not specified. Two-thirds of the reservoirs where the gull was recorded or bred were located in the European part and only 1/3 in Asia. It is assumed that up to 5000 adults (0.45%-4.0% of the global population of the species) breed annually in the reservoirs of the Palearctic, and the reservoirs are not the main habitats for maintaining and reproducing the population of the species. The majority of the breeding population reproduces in natural water bodies, and the reservoirs of the Palearctic are important for the maintenance of non-breeding individuals. Detection of presumed breeding and new breeding colonies in reservoirs north of the historical range of the species has been established on the Russian Plain, in the Urals and Trans-Urals. The reservoirs of Russia play a leading role in providing breeding sites for the species in water bodies of this type. An analysis of the data allows us to state the important and increased role of reservoirs in the modern distribution and expansion of the range of the Pallas's Gull in the Palearctic.

Keywords: Great Black-headed Gull; Damming

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1. Introduction

River birds are becoming more often objects of research on river ecosystems [1], although data on the study of river taxa, communities, and the impact of river flow regulation on birds are not so extensive [2,3]. Most studies on the possible effects of river regulation and the effects of hydroelectric power plants on birds are speculative [2]. The creation of reservoirs can benefit some bird species and threaten others. Fluctuations in the water level in reservoirs can adversely affect the avifauna [2]. The reservoir can become a physical barrier for many animals, although birds are very mobile, individuals in many populations can be separated [4]. Damming is a disturbance that seems very unpredictable for animals, and they are not able to adapt to such anthropogenic disturbances, as in natural disasters [4]. It is important to improve our understanding of the relationship between birds and dams through a scientific approach to the study of this problem [4].

Reservoirs are man-made water bodies, the water level in which is controlled by man through the operation of hydraulic structures. Flow regulation is the main goal of creating any reservoir [5]. The formation of reservoirs has become a planetary phenomenon since the second half of the 20th century, and by the end of the 1980s, more than 30,000 reservoirs arose with the help of man, and in the future, it is planned to regulate 2/3 of the world's rivers [5]. At present, most of the large reservoirs are located in Russia (formerly the USSR), Canada, China, India, and the USA [4].

The Pallas's Gull *Ichthyaetus ichthyaetus* (Pallas, 1773) is one of the largest and most spectacular fish-eating predators among the world's gulls. The breeding area of the species is located entirely in the Palearctic, inside the continent. By the beginning of the 21st century, the range of the Pallas's Gull extended from the Black and Azov Seas in the west to the Great Lakes in Mongolia and Uryugnor in China in the east [6]. Non-breeding individuals were mainly found in the breeding area of the species and to the south (including south of the southern border of the Palearctic region), although some non-breeding individuals in the north reached 58°N [7,8]. The Pallas's Gull belongs to the Mediterranean type of fauna [9]. It inhabits marine, freshwater and terrestrial biomes. The state of the global population of the species is assessed as the least threatened with a positive trend in population growth [10]. The most important and largest place of colonial breeding of the species in the world is located in Russia in the Northern Caspian Sea [11], where from 50% to 90% of the Russian breeding population bred in different seasons on the Maly Zhemchuzhny Island [12], and the maximum colony size (42,000 breeding pairs) was recorded in 1987 [11]. On a large territory of Eurasia, some of its local breeding populations are rare, vulnerable and listed in the Red Books of some countries, for example, Russia, Ukraine, Kazakhstan, Uzbekistan, Kyrgyzstan. The relevance of this study lies in obtaining new information about the state of local populations of the Pallas's Gull in the reservoirs of the Palearctic in a changing climate and steadily increasing anthropogenic pressure on natural ecosystems, including the progressive regulation of river flows [5].

The aim of the study was to assess the current state of the Pallas's Gull in the reservoirs of the Palearctic. The objectives of the review were (1) to collect facts about the number of reservoirs visited or used by these gulls and (2) to establish the status of the Pallas's Gull in the reservoirs. Special attention was also focused on the questions: (1) can the reservoirs of the Palearctic be considered as the most important habitats for the maintenance and reproduction of the population of the species and (2) what is the significance of reservoirs in its modern distribution? The study complements and expands our understanding of the state of the Pallas's Gull in the reservoirs of the Russian (East European) Plain, Cis-Urals, Trans-Urals and Siberia [8,13-27]. The purpose of the study was achieved.

2. Materials and methods

The work is based on recent field observations of the author and other researchers, as well as a compilation of already published knowledge. The basis of this article was publications in Russian and English, which were found using the search engines Yandex,

Google, Google Scholar, eLybrary. The following keywords and phrases were used in the search: черноголовый хохотун, водохранилище, Larus ichthyaetus, *Ichthyaetus ichthyaetus*, Pallas's Gull, Great Black-headed Gull, reservoir. I looked through 1030 literary sources, which contained information about the Pallas's Gull within the borders of the Palearctic. Reservoirs where the Pallas's Gull was recorded, located to the south of this zoogeographical area, for example, in India Vyas, R., Singh, H. [28] were not included in the scope of the research questions. About 50 publications in hard copies outside the open Internet access were considered. The review included publications where observations of the Pallas's Gull directly indicated a specific reservoir, with the exception of the Kama and Votkinsk reservoirs. The status of a species (breeding, non-breeding) was determined mainly from publications. At the end of the search, a catalog of reservoirs visited by the Pallas's Gull was compiled (**Table 1**).

In the catalog, the status of a species in a particular reservoir was accompanied by only 1-2 selected references. This made it possible to significantly reduce the volume of the list of cited publications. Catalog visualization is shown in **Figure 1**.

Table 1. Status of the Pallas's Gull (*Ichthyaetus ichthyaetus*) in the reservoirs of the Palearctic.

№	Reservoir name	Area (km²)	Country	Coordinates	Status	Source
1	Aksautsk	0.3	Russia	43°47'24" N, 41°41'22" E	NBr	[29]
2	Argazinsk	84.4	Russia	55°23'45" N, 60°22'45" E	NBr	[19]
3	Bekan	0.65	Russia	43°15' N, 44°16' E	NBr	[30]
4	Beloyarsk	38	Russia	56°51'53" N, 61°15'20" E	NBr	[18]
5	Bratsk	5470	Russia	56°15'0" N, 101°45'0" E	NBr	[23,24]
6	Bredinsk	13.2	Russia	52°27'9" N, 60°12'29" E	NBr	[31]
7	Budennovsk	7.4	Russia	44°49'18" N, 44°8'40" E	+	[32]
8	Cheboksary	2190	Russia	56°18'00" N, 46°43'00" E	NBr	[33]
9	Chogray	193	Russia	45°29'17" N, 44°35'56" E	Br	[34,35]
10	Dimitrovsk	0.56	Russia	51°29'24" N, 54°10'39" E	NBr	[36]
11	Dundinsk	18	Russia	45°55'20" N, 43°00'40" E	+	[32]
12	Gilevsk	65	Russia	51°5'41" N, 81°54'48" E	NBr	[37]
13	Gorky	1591	Russia	57°29'00" N, 42°06'00" E	NBr	[15,16]
14	Gorodovikovsk	21.24	Russia	45°58'54" N, 42°9'42" E	+	[32]
15	Iriklinsk	260	Russia	51°51'16" N, 58°47'22" E	Br	[20]
16	Kama	1915	Russia	58°08'00" N, 56°21'00" E	NBr	[7]
17	Krasnodarsk	420	Russia	44°59'36" N, 39°17'38" E	NBr	[38]
18	Krasnoyarsk	2000	Russia	55°00'00" N, 91°38'29" E	NBr	[22]
19	Kubansk	50	Russia	44°13'48" N, 42°16'12" E	NBr	[39,40]
20	Kurgansk	-	Russia	55°24'23" N, 65°11'34" E	NBr	[32]
21	Kuibyshevsk	6250	Russia	53°27'00" N, 49°10'00" E	Br	[25,26]
22	Kursk (Kurchatovsk)	21.5	Russia	51°40'37" N, 35°40'26" E	NBr	[32]
23	Makansk	-	Russia	51°56'5" N, 58°24'6" E	NBr	[41]
24	Marukhsk	0.15	Russia	43°47'21" N, 41°39'34" E	NBr	[29]
25	Mehteb	25	Russia	43°19'38" N, 47°25'59" E	NBr	[42]
26	Naslednitsk	21.2	Russia	52°09'45" N, 60°20'06" E	NBr	[43]
27	Nizhnekamsk	1370	Russia	55°53'00" N, 52°45'00" E	NBr	[44]
28	Novosibirsk	1070	Russia	54°38' N, 82°38' E	Br	[21]

Table 1 continued

№	Reservoir name	Area (km²)	Country	Coordinates	Status	Source
29	Novotroitsk	18	Russia	45°17’38” N, 41°31’09” E	+	[32]
30	Otkaznensk	21.6	Russia	44°18’00” N, 43°49’40” E	+	[32]
31	Penza	110	Russia	53°01’45” N, 45°15’35” E	NBr	[45]
32	Proletarsk	510	Russia	46°23’40” N, 42°34’28” E	Br	[46]
33	Rostovanovsk	4.5	Russia	43°59’30” N, 44°11’19” E	+	[32]
34	Rybinsk	4550	Russia	58°22’30” N, 38°25’04” E	NBr	[8,47]
35	Saratov	1831	Russia	52°32’48” N, 48°10’15” E	NBr	[48]
36	Sayano-Shushensk	621	Russia	52°05’57” N, 92°13’58” E	NBr	[49]
37	Sengileevsk	42	Russia	45°02’16” N, 41°44’29” E	+	[32]
38	Shershnevsk	39	Russia	55°06’ N, 61°18’ E	NBr	[50,51]
39	South Ural	17.2	Russia	54°29’10” N, 61°14’12” E	NBr	[50]
40	Sovetsk	5.8	Russia	44°1’26” N, 43°59’56” E	+	[32]
41	Starooskol	40.9	Russia	51°23’28” N, 37°46’53” E	NBr	[53]
42	Tsimlyansk	2702	Russia	47°50’ N, 42°50’ E	Br	[54]
43	Ust-Dzhegutinsk	2.67	Russia	44°2’16” N, 41°57’24” E	NBr	[29]
44	Veselovsk	238	Russia	47°06’30” N, 40°54’47” E	NBr	[55]
45	Volchikhinsk	37.1	Russia	56°48’00” N, 60°07’00” E	Br	[17]
46	Volgograd	3117	Russia	50°19’10” N, 46°11’13” E	Br	[56]
47	Votkinsk	1120	Russia	57°10’00” N, 55°00’00” E	NBr	[13]
48	Yachen	2.3	Russia	54°31’18” N, 36°13’34” E	NBr	[14]
49	Yegorlyksk	17	Russia	45°3’8” N, 41°38’6” E	+	[32]
50	Troitsk	10.85	Russia-Kazakhstan	54°00’59” N, 61°40’00” E	NBr	[19]
51	Bitiksk	35	Kazakhstan	50°16’11” N, 50°41’58” E	Br	[57]
52	Bukhtarma	54.9	Kazakhstan	49°10’00” N, 84°15’00” E	NBr	[58]
53	Reservoir east of the village of Ayuly	-	Kazakhstan	49°58’51” N, 74°16’22” E	NBr	[59]
54	Shardara (Chardara)	783	Kazakhstan	41°12’01” N, 67°59’54” E	NBr	[60,61]
55	Tashutkol	78	Kazakhstan	43°21’56” N, 73°56’23” E	NBr	[62]
56	Tekes	-	Kazakhstan	42°49’46”N 80°7’9” E	NBr	[63]
57	Jeziorsko	19.6	Poland	51°50’00” N, 18°40’00” E	NBr	[64] cited in: [65]
58	Dneprovsk (Zaporozhsk)	410	Ukraine	47°57’36” N, 35°06’52” E	Br	[66,67]
59	Kakhovsk	2155	Ukraine	47°30’ N, 34°06’ E	NBr	[67]
60	Kremenchug	2252	Ukraine	49°17’51” N, 32°34’58” E	Br	[27]
61	Pechenezhsk	86.2	Ukraine	49°54’35” N, 36°58’56” E	NBr	[68]
62	Araz (Araksk)	145	Azerbaijan	39°09’47” N, 45°20’10” E	NBr	[69]
63	Khauzhan	210	Turkmenistan	37°13’56” N, 61°14’37” E	NBr	[70] cited in: [66]

Note: Br—breeding; NBr—non-breeding; “+”—birds have been recorded but status unclear.

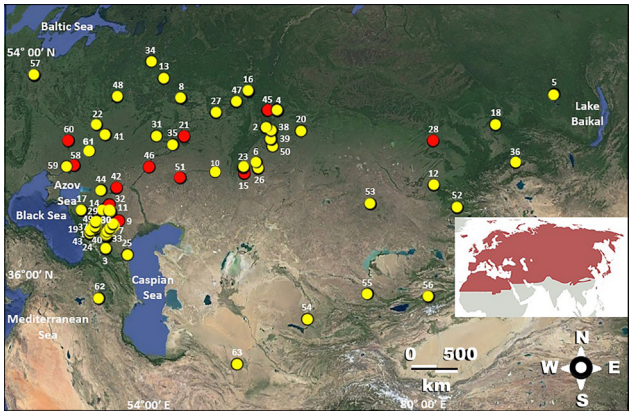

Figure 1. Distribution of the Pallas's Gull (*Ichthyaetus ichthyaetus*) in the reservoirs of the Palearctic.

Note: Red circles represent reservoirs where the Pallas's Gull breeds; yellow circles indicate reservoirs where non-breeding individuals have been observed; in the right inset, the Palearctic region is highlighted in brown.

From 1986 to 2022, the author carried out numerous foot, car and water expeditions across the territory of the Russian Plain, Siberia to the east to Lake Baikal, as well as in the Caucasus, Ciscaucasia, Transcaucasia, North Africa, Minor Asia and Central Asia, the islands of the Persian Gulf. This made it possible to better imagine the living conditions of the Pallas's Gull in the space of its range and to supplement the material of the current report. The area size and distance (on the surface of the earth) between some reservoirs were calculated using Google Earth Pro. Breeding in reservoirs was considered established if nests with egg clutches, chicks or flightless young were found. In this work, the term reservoir was used in a broad sense, that is, the area of the reservoir formed by the dam varied from 0.15 km^2 to several thousand km^2.

3. Results and discussion

3.1 The number of reservoirs where the Pallas's Gull was recorded and its status on them

During the last predominantly 35 years, the Pallas's Gull has been found in at least 63 reservoirs of the Palearctic (**Table 1**, **Figure 1**). Breeding was found in 11 (17.4%) reservoirs, breeding was not found in 43 (68.2%) reservoirs, and birds were present in 9 (14.2%) reservoirs, but their local status was not indicated in the publications. Forty-seven reservoirs (74.6%) visited by Pallas's Gull were located in Russia, 6 (9.5%) in Kazakhstan, 1 (1.5%) on the border of Russia and Kazakhstan, 4 (6.3%) in Ukraine, one each (1.5%) in Azerbaijan, Turkmenistan and Poland. On the Russian Plain, Pallas's Gull bred in 8 (72.8%) reservoirs, in the Trans-Urals and Western Siberia in 3 (27.2%) reservoirs. In Russia, the gull bred on 8 (72.8%) reservoirs, in Ukraine on 2 (18.2%) and in Kazakhstan on one (9.0%). The maximum number of reservoirs where these gulls bred was found on the Russian Plain (n = 8). A clear downward trend in breeding in the reservoirs was observed from west to east. A similar trend was observed in reservoirs where the gull did not breed. Two-thirds of the reservoirs where the gull was recorded or bred were in the European part and only 1/3 in the Asian part. This indicates more favorable environmental conditions for the distribution of the gull in the European part than in the Asian part.

3.2 Can the reservoirs of the Palearctic be considered as the most important habitats for the maintenance and reproduction of the population of the species?

About 1/6 (11 reservoirs) of the total number of reservoirs visited by the Pallas's Gull (n = 63) were suitable for breeding, as mentioned above. The maximum size of breeding colonies was established: (1) on the Russian Plain in the Kuibyshevsk reservoir of the Volga-Kama cascade of reservoirs [25,26]; (2) in the Trans-Urals at the Iriklinsk reservoir [20]; (3) in Western Siberia on the Novosibirsk reservoir [21]. Thus, the reservoirs of Russia play the most important role in the reproduction of this species in reservoirs. Taking into account that in some reservoirs in different breeding seasons, from 1-10 (Dneprovsk, Kremenchug, Volchikhinsk) to several hundred (Kuibyshevsk) and more than a thousand (Novosibirsk, Iriklinsk) nests/breeding pairs were found [17,20,21,25-27,67], it is assumed that annually in the reservoirs of the Palearctic can breed up to 5,000 adults, representing 0.45%-4% of the species' total population size, esti-

mated at 125,000 to 1,100,000 individuals [10]. Based on these data, an insignificantly small part of the population can breed annually in the reservoirs of the Palearctic. Consequently, the majority of the breeding population of the Pallas's Gull reproduces in natural water bodies, less affected by anthropogenic influence, which confirms their value in maintaining and preserving the population of the species in the current time. The general estimate of the number of non-breeding Pallas's Gulls that annually inhabit or visit the reservoirs of the Palearctic undoubtedly exceeds the number of breeding birds and can be in the tens of thousands of individuals. However, a general estimate of the number of non-breeding individuals has not yet been obtained. From the foregoing, it follows that the reservoirs of the Palearctic are primarily important for maintaining the non-breeding part of the Pallas's Gull population.

3.3 The importance of reservoirs in the modern distribution of the species

The results of the review indicate a very significant area of the Palearctic region, the reservoirs of which were visited by the Pallas's Gull. The area where the Pallas's Gull bred (1.209.199 km^2) turned out to be 5.2 times smaller than the total area of the reservoirs where the gull was recorded (6.335.570 km^2). The Jeziorsko reservoir was the most western, the Rybinsk reservoir the most northern, the Bratsk reservoir the most eastern, and the Khauzkhan reservoir the most southern, where the gull did not breed. The distance between the northernmost (Rybinsk) and southern (Khauzkhan) reservoirs was 2899 km, and between the most western (Jeziorsko) and eastern (Bratsk) reservoirs was 5124 km.

Over the past 30 years, the Pallas's Gull has settled to the north and east [12]. The suggestion that it has been able to breed in reservoirs and may expand its range in the future [66] is supported by the results of this survey. The current breeding limits of the species in the reservoirs of the Palearctic are between 45°N and 56°N and 32°E and 82°E, although in the European part of Russia, for example, the northern limit of the distribution of the species reached only 47°N by the beginning of the 21st century [6]. To date, the proposed breeding [36] and new breeding colonies in reservoirs north of the historical range of the species have been established on the Russian Plain (for example, Bekmansurov, R.Kh. et al. [25-27], in the Cis-Urals and Trans-Urals [17,36]. The expansion of the breeding range to the north and east was observed in water bodies (not reservoirs) in the south of Central Siberia in the Altai-Sayan region [71] and, possibly, in Eastern Siberia [23]. However, there are no data on the breeding of the Pallas's Gull yet in the reservoirs of Central and Eastern Siberia, although breeding is allowed in the Bratsk reservoir [22,23].

It should be noted that the reservoirs of the Palearctic are not the only water bodies along which the species spread to the north and east. Settlement is also facilitated by the increase in the number of fish ponds that attract gulls, with some ponds actually being reservoirs in the broadest sense. Against the backdrop of climate warming and along with reservoirs, fish-breeding ponds and other fish breeding grounds rich in fish resources, as well as industrial fishing in fresh water bodies, have become one of the determining factors in the modern distribution of the Pallas's Gull outside its recent (historical) range and the redistribution of local breeding populations within the range. Fish-rich artificial reservoirs compensate gulls for missing or deficient ecosystem services outside the species' optimum range. This aspect is not considered in detail in the work and deserves a separate discussion.

In general, the analysis of the materials allows us to state the important and increased role of reservoirs in the modern distribution and expansion of the range of the Pallas's Gull in the Palearctic. In reality, Pallas's Gulls interact with a large number of existing reservoirs. Undoubtedly, the list of such reservoirs can be expanded in the near future if experts from the regions who have up-to-date information on the local state of the species join the project. Some published sightings of the Pallas's Gull on rivers and lakes may also refer to fragments of reservoirs not included in the catalog of this review. Given the above circumstances, the results of the review can

be considered as preliminary and as the next stage of further research efforts in assessing the current state of the species population in a changing environment. However, even if the list of reservoirs grows soon, this is unlikely to change the main conclusions contained in the proposed article.

Despite the relative well-being of the Pallas's Gull population, monitoring of this species should continue. Particularly relevant to me is the publication of comprehensive reviews of historical and recent records of Pallas's Gulls in reservoirs. Such reviews exist [21,45], but they are few and may be limited to even one or a few registrations [8,14,23,47,52]. Such data are relevant for understanding the general patterns of the development of reservoirs by the Pallas's Gull, the level in which is regulated by humans, and the number of reservoirs continues to increase, changing the appearance of the hydrosphere. Prospects for further study of the Pallas's Gull may be associated with the study of the characteristics of its ecology in fish ponds and their role in the spread to the north, the search for new colonies outside the range of the species, the survey of more reservoirs, the study of migrations and the ecology of non-breeding birds, determining the size of non-breeding populations in reservoirs using a unified accounting methodology.

4. Conclusions

During the last 35 years, the development of reservoirs by the Pallas's Gull continued. This trend is likely to continue in the near future. The number of reservoirs that will be used for breeding is unlikely to increase markedly in immediate prospects. In most existing reservoirs, the Pallas's Gull does not breed because environmental conditions do not meet the requirements of its breeding population. These requirements are reduced to a combination of a set of basic conditions: to the presence of an unstable water level in a reservoir; to the presence of islands suitable for breeding and colonies of other bird species on them, usually large white-headed gulls; to the presence of shallow waters and an abundance of available food, mainly fish; to the absence or minimal presence of human activity and the absence of threats from predators. Combinations of such conditions are not unique, but are rare in most reservoirs outside the historical range of the species. Apparently, they are the main limiting reason for restraining the growth and spread of the breeding population of gulls in reservoirs.

Conflict of Interest

The author declares that there is no conflict of interest.

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