Changes in birds’ demographic parameters of a key ornithological territory “Tract Trekhozerki” (Minusinsk basin) with fluctuations in water level

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Abstract. Today “Tract Trekhozerki” is a state natural zoological reserve of regional importance. The tract is home to over 100 species of birds, including 12 species listed in the Red Book of the Russian Federation. For five bird species, breeding information was obtained over the period from 2013 to 2018. In two species of gulls (Larus argentatus mongolicus Suskin, 1925 and Larus ichthyaetus), the abundance changes were similar: the number of breeding pairs decreased (in the second species to 0) from 2013 to 2015, and then there was an increase in numbers. The population of Ardea cinerea has decreased. Recurvirostra avosetta breeds irregularly in the tract, with 73 pairs nesting in 2018. For all these species, a decrease in the average size of masonry in years with a low water level was noted. Phalacrocorax carbo nesting were noted only in 2013 and 2014. The changes in abundance are associated with cyclical fluctuations in the water level in water bodies: a decrease from 2013 to 2015 and a subsequent increase until 2018. This affected the availability of nests, the area of habitats suitable for nesting, and species competition. For species of birds listed in the Red Book of the Russian Federation (L. ichthyaetus and R. avosetta), the high, but not the maximum degree of watering observed in 2013 and 2018 is most favorable.

1. Introduction
“Tract Trekhozerki” is recognized as a key ornithological territory of international importance, which is confirmed by posting information about it on the site of the Russian Bird Conservation Union [1]. It is included in the Perspective List of the Ramsar Convention (the “Shadow List” of Wetlands of International Importance), together with the reservoirs of the “Tract Sorokaozerki”, under the general name “Lakes of the Koibal Steppe” [2].

Since 2014, the tract has become a specially protected natural area of regional importance - the state natural zoological reserve “Tract Trekhozerki”.

The interest of nature conservation institutions, individual scientists, and entire research teams in this wetland has not diminished for more than 20 years [3–12]. The reason lies in the high species diversity of birds and the conservation significance of “Tract Trekhozerki”. Due to the high ecological capacity, more than 100 species of birds live in the tract, including 12 species listed in the Red Book of the Russian Federation (2001) [13] and 32 species in the Red Book of the Republic of Khakassia (2014) [14]. Here there is the only permanent settlement in Minusinsk Basin Larus ichthyaetus Pallas, 1773 and one of the main nesting sites of Recurvirostra avosetta Linnaeus, 1758 bird species listed in the Red Book of the Russian Federation and regional Red Books: Krasnoyarsk Territory (2012) [15], Republic of Khakassia
and the Republic of Tuva (2018) [16]. Large migratory assemblages of cranes (Grus grus (Linnaeus, 1758), Anthropoides virgo (Linnaeus, 1758), Grus monacha Temminck, 1835), swans, waders (Philomachus pugnax (Linnaeus, 1758), Calidris minuta (Leisler, 1858)), geese and many other species of birds in the wetland complex.

Over the course of six years (2013–2018), observations on the species composition and number of breeding bird species of the reserve were made. Some of the results were published [9, 17–20]. Unpublished data for 2018 in terms of six-year dynamics are presented in this paper.

The purpose of the work is to characterize a six-year dynamics of the abundance and size of the clutch of five species of nesting birds of the state natural zoological reserve “Tract Trekhozerki” in the aspect of cyclic changes in water level.

2. Materials and methods
Wetland formed in the 60s of the twentieth century. The filling of the main channel of the Koibal irrigation system with river water led to the formation of a number of lakes in the swampy lowlands. There is Lake Black and Lake Bugayovo located 1 kilometer from the tract among them. Due to the underground filtration of water from neighboring lakes, the beds of which are 3-5 meters higher in relief, and an increase in the amount of precipitation, the tract was flooded. Under the influence of arid climate, water bodies became hyperhaline.

The area of the reserve “Tract Trekhozerki” is 1348.5 hectares. The coordinates of the central point are 91.500556 N, 53.316667 E.

The area is a zero-discharge, swampy hollow, the bottom of which is composed of lake loams and clays up to 10m thick. The filtration parameters of bed rocks are currently very low, and therefore, groundwater recharge is negligible. Ponds have mainly atmospheric nutrition; in addition, in the warm season in the southwestern part, 1.5 km from the center of the tract, there is a spring. In the autumn-winter period, the water level is higher, in the summer period it decreases by about 0.18 m. Mineralization changes throughout the year and over the course of a number of years in the range from 80 to 200‰.

The number of reservoirs, their area, boundary configuration and depth vary annually depending on the amount of precipitation (figure 1). The water area of the main body of water in different years varies from 0.5 to 2.9 km²; the maximum depth is from 0.7 to 1.8 meters. Shores and islands are mostly muddy, viscous. The highest areas are occupied by halophytic vegetation.

The study of the avifauna of the wetland was carried out in 2013–2018. The main observations were dedicated to the incubation period of gulls - the founders of the colonies on the islands: the first decade of May. Additional observations were carried out in April and the second half of May (at least 1 time in 2 weeks) and from August to October (at least 1 time per month).

During the nesting period of birds, the search for residential nests by a thorough inspection of all territories suitable for nest construction on islands and along the banks of water bodies was made. To minimize the anxiety of birds, the nests were inspected once at the very height of incubation (May 1–12). In 2018, due to the late terms of observations, it was not possible to determine the size of the clutch of gulls.

Due to the fact that when determining the size of the clutch the whole population was studied, the arithmetic mean error was not calculated.

On subsequent visits to the same territories, breeding bird colonies were examined only with binoculars, from a distance at which bird disturbance did not occur.

Remote observations were carried out using BPC binoculars 10x40 with a 10-fold increase. The photographs were taken using an Olimpus-420 camera. The names of bird species, with the exception of the form Larus argentatus mongolicus Suskin, 1925, are given according to L S Stepanyan [21].

The taxonomy of the white-headed gulls of the species Larus remains controversial among taxonomists [22–25]. There is no unequivocal opinion regarding the form(s) that live in the study area [10, 26]. Without claiming to be absolute truth, the white-headed gulls of “Tract Trekhozerki” are taken
as the form *Larus argentatus mongolicus* Suskin, 1925 (according to L S Stepanyan [21] - *L. cachinnans mongolicus*).

For figure 1, satellite images of the Landsat 8 type were used, obtained from the Remote Sensing Data Download Service of the US Geological Survey [27]. The resolution of the images was 1:15; decryption was carried out according to the method of S M Chivilev, et al. [28]. A comparison was made between the coordinates of the satellite image and GPS coordinates: accuracy of coincidence of ± 7 meters.

![Satellite Images](image1.png)

**Figure 1.** “Tract Trekhozerki” space images (1:50 000): a) 14.05.2015, b) 25.05.2016, c) 26.04.2017, d) 29.04.2018.

3. Results
On the territory of the wetland for the entire period of ornithological studies, no less than 116 species of birds were recorded [9]. Most of these species stay in the tract only during the period of migration. Over six years of observations, the authors noted 63 species; nesting was established for 25 species.

Among the nesting birds, the most numerous group of the wetland complex is 14 species: *Phalacrocorax carbo* (Linnaeus, 1758), *Ardea cinerea* Linnaeus, 1758, *Tadorna ferruginea* (Pallas, 1764), *T. tadorna* (Linnaeus, 1758), *Aythya ferina* (Linnaeus, 1758), *Anthropoides virgo* (Linnaeus, 1758), *Charadrius dubius* Scopoli, 1786, *Vanellus vanellus* (Linnaeus, 1758), *Recurvirostra avosetta* Linnaeus, 1758, *Larus argentatus mongolicus* Suskin, 1925, *Larus ichthyaetus* Pallas, 1773, *Acrocephalus agricola* (Jerdon, 1845), *Panurus biarmicus* (Linnaeus, 1758), *Emberiza schoeniclus* (Linnaeus, 1758).

The reservoirs of the natural boundary are hyperhaline, therefore fish-eating birds (gulls, herons) feed from freshwater lakes outside the protected areas. Wetland islands are a breeding ground for birds.

For five mass species, each year it was possible to establish the absolute number of breeding pairs and the size of sets.

*L. argentatus mongolicus* is the most numerous breeding species. They are settled exclusively on islands inaccessible from the coast. Colonies in the tract have been known since 1989 [11].
Over a six-year observation period, the maximum abundance was noted in 2013 (figure 2). The decrease in the number of breeding pairs in the next two years is probably associated with a decrease in the number of suitable territories. 2014 and 2015 years were characterized by the lowest water level, resulting in the availability of islands for predators (figure 1).

In the next three years, in parallel with rising water levels, the number of breeding *L. argentatus mongolicus* steadily increased. With the maximum water cut observed in 2018, the number of breeding pairs did not reach the previous level, probably again due to a decrease in the area of suitable territories: some of the islands were completely hidden by water, the area of the remaining ones decreased sharply.

In years with a low water level, the average size of the clutch of *L. argentatus mongolicus* was significantly lower due to an increase in the proportion of sets in 1 and 2 eggs (table 1). Sets consisting of 4 or 5 eggs are probably the result of intraspecific parasitism. The proportion of such sets was higher in years with a high number of pairs (table 1, figure 2).

$L. ichthyaetus$, as a species of the Red Book of the Russian Federation and regional red books, has always attracted special attention of researchers. Its nesting site has been known in “Tract Trekhozerki” since 1988 [29], then 11 pairs were discovered.

In the study period, the maximum number of nesting birds was observed in 2017 (figure 2). Over the previous 24 years (1989–2012), the largest number was recorded in 2010 - 325 pairs (O N Melnik, oral communication). That year was characterized by a high level of water in the tract. In two dry years (2014 and 2015), *L. ichthyaetus* did not nest, although 2–8 birds were found on all days of work. The cessation of nesting of this species in years with a low water level was noted earlier [9].

![Figure 2. Number of breeding pairs of gulls.](image_url1)

![Figure 3. Number of breeding pairs.](image_url2)

| Year | Number (pieces) of nests with the number of eggs (in parentheses, percentage, %) | Average value |
|------|---------------------------------------------------------------------------------|---------------|
|      | 1 | 2 | 3 | 4 | 5 |                      |
| 2013 | 9 (19) | 39 (8.4) | 411 (88.0) | 6 (1.3) | 2 (0.4) | 2.9 |
| 2014 | 239 (36.2) | 232 (35.1) | 187 (28.3) | 2 (0.3) | 0 | 2.0 |
| 2015 | 83 (39.5) | 44 (21.0) | 82 (39.0) | 1 (0.5) | 0 | 2.0 |
| 2016 | 34 (5.0) | 83 (12.1) | 568 (82.8) | 1 (0.1) | 0 | 2.8 |
| 2017 | 62 (8.0) | 128 (16.4) | 564 (72.6) | 23 (3.0) | 0 | 2.7 |

Further dynamics of the abundance of *L. ichthyaetus* is similar to that for the silver gull; only in 2018 there was no increase, but a decrease in the number. It can be explained by the fact that in the wettest year, the only island on which the colony *L. ichthyaetus* was located in the previous 5 years was hidden...
by water (figure 1). Black-headed laughers moved to the islands occupied by silver gull, where they were probably experiencing a shortage of places and competition.

In the first year after the resumption of nesting, it was noted that *L. ichthyaetus* had a smaller size of the clutch (table 2).

| Year | Number (pieces) of nests with the number of eggs (in parentheses, percentage, %) | Average value |
|------|---------------------------------------------------------------------------------|---------------|
| 2013 | 8 (2.8) 22 (7.6) 259 (89.3) 1 (0.3)                                            | 2.9           |
| 2016 | 37 (9.3) 114 (28.6) 245 (61.6) 2 (0.5)                                         | 2.5           |
| 2017 | 43 (6.6) 80 (12.3) 524 (80.7) 2 (0.3)                                          | 2.8           |

In the tract *A. cinerea* always arranged nests in gull colonies. For more than a twenty-year period of ornithological observations, the maximum number of nesting herons was recorded in 2010 (114 pairs) [9]. The abundance of *A. cinerea* was affected by fluctuations in the water level and movements of the nests of gulls (figure 3). In the “critical” years of 2014 and 2015, when the islands became accessible to terrestrial predators, gray herons nested not on the islands, but in the flooded territories, placing the tray above the water level. Water level rise in 2016–2018 led to the fact that the majority of gray herons began to nest on trees in nearby forest belts, outside the reserve.

The species *R. avosetta* is characterized by inconsistency of nesting sites and the number of nesting pairs (figure 3). In 2014 and 2016 nests were located directly on the banks of the main body of water, on marshy mud beaches. In a wet year of 2018, probably due to the lack of shallow water and mud beaches, the colony was founded in the southeastern part of the tract, a few hundred meters from the main body of water, in a swampy meadow.

For *A. cinerea* and *R. avosetta* in the dry year of 2014, a smaller size of the clutch was noted (tables 3, 4).

| Year | Number (pieces) of nests with the number of eggs (in parentheses, percentage, %) | Average value |
|------|---------------------------------------------------------------------------------|---------------|
| 2013 | 0 2 (4.1) 3 (6.1) 19 (38.8) 25 (51.0) 0                                          | 4.3           |
| 2014 | 18 (28.6) 8 (12.7) 15 (23.8) 1 (1.6)                                            | 2.7           |
| 2015 | 1 (6.3) 0 9 (56.2) 5 (31.2) 0                                                  | 4.0           |

In 2013, the first attempt was made to nest *P. carbo* in “Tract Trekhozerki”, which was unsuccessful. In 2014, a dense settlement of 15 nests was found in the same territory, 9 of them with the clutch [18]. 2–7 adult cormorants were met in May 2015–2017, but nests and the clutch were not found. In May 2018, about 60 *P. carbo* individuals were constantly kept in the tract, which flew to feed on the neighboring lake Black. A complete survey of all territories suitable for the construction of cormorant nests within the boundaries of the natural boundary has not yielded results. Birds may not have nested due to the high density of gulls on the islands.

| Year | Number (pieces) of nests with the number of eggs (in parentheses, percentage, %) | Average value |
|------|---------------------------------------------------------------------------------|---------------|
| 2013 | 11 (23.4) 10 (21.3) 15 (31.9) 7 (14.9) 4 (8.5)                                  | 2.6           |
| 2014 | 1 (16.7) 2 (33.3) 3 (50.0) 0 0                                                 | 2.2           |
| 2018 | 6 (8.6) 8 (11.4) 15 (21.4) 39 (55.7) 2 (2.9)                                  | 2.4           |
4. Conclusion
Wetland “Tract Trekhozerki” experiences long-term cyclic fluctuations in water level, which affects the suitability of the territory for bird nesting: with a maximum decrease in water level, the islands connect to the coast and cease to be inaccessible, with an increase - part of the area used for nesting goes under water. These abiotic factors and competitive relationships between colonial species determine the abundance dynamics of *L. argentatus mongolicus*, *L. ichthyaetus*, *Ardea cinerea* and *Recurvirostra avosetta* and the size of their size of the clutch.

For species of birds listed in the Red Book of the Russian Federation (*L. ichthyaetus* and *R. avosetta*), the high, but not the maximum degree of watering observed in 2013 and 2018 is most favorable.

References
[1] Trekhozerki lakes RU3033 2020 BirdLife International. URL: http://datazone.birdlife.org/site/factsheet/trekhozerki-lakes-iba-russia-(asian)
[2] Wetlands listed on the Ramsar Prospective List (Shadow List of Wetlands of International Importance): Wetlands of Russia 3 http://www.fesk.ru/tom/3.html
[3] Kutyanina A V, Savchenko A P and Karpova N V 1997 On the nesting of laughter and black-headed laughter in “Tract Trekhozerki” (Khakassia) *Vestnik of Khakass State University named after N F Katanov* Series 4 Biology, Medicine Chemistry IV 32-4
[4] Baikalov A N, Baykalova T N and Korovitsky E M 1997 Spring-summer ornithofauna of “Tract Trekhozerki” *Vestnik of Khakass State University named after N F Katanov* Series 4 Biology, Medicine Chemistry IV 23-6
[5] Kutyanina A V and Karpova N V 2005 Influence of water level fluctuations on the nesting of colonial bird species in “Tract Trekhozerki” *Proceedings of the interregional scientific-practical conference “Association of the Russian Federation and the problems of nature management in Yenisei Siberia”* (April 11-13, 2005 y.) pp 197-8
[6] Melnik O N and Baranov A A 2006 Territorial distribution, population dynamics, and breeding biology of black-headed laughter (*Larus ichthyaetus* Pall.) in Minusinsk basin *Vestnik of Buryat State University Special series* 4 155-63
[7] Baranov A A and Melnik O N 2009 Black-headed laughter *Larus ichthyaetus* Pall. and silver gull *Larus argentatus mongolicus* Sushkin in the Altai-Sayan ecoregion *Modern problems of ornithology in Siberia and Central Asia* 38-45
[8] Melnik O N 2013 Dynamics of the abundance of background species of birds of “Tract Trekhozerki” (Koibal steppe, Khakassia) *Fauna and ecology of animals of Siberia* 144-53
[9] Melnik O N, Geld T A and Zlotnikova T V 2015 Dynamics of the number of colonial bird species in “Tract Trekhozerki” (Minusinsk basin) *Vestnik of Krasnoyarsk State Agrarian University* 1 45-50
[10] Kucherenko A V 2016 Nesting of subspecies of a silver gull in the south of Central Siberia *Successes in modern science and education* 11(6) 156-9
[11] Savchenko A P, Emelyanov V I, Karpova N V, Savchenko P A and Kucherenko A V 2016 Lake and silver gulls in the territory of Khakassia *Successes in modern science and education* 5(2) 156-9
[12] Savchenko P A, Kucherenko A V and Karpova N V 2016 On the expansion of the silver gull in the south of Central Siberia *Vestnik of Krasnoyarsk State Agrarian University* 8 86-9
[13] *The Red Book of the Russian Federation. Animals* 2001 Ministry of Natural Resources of the Russian Federation, Russian Academy of Sciences (M.: AST: Astrel)
[14] *The Red Book of the Republic of Khakassia Rare and Endangered Species of Animals* 2014 (Krasnoyarsk-Abakan: publishing house of Siberian Federal University)
[15] The Red Book of the Krasnoyarsk Territory 2012. *Rare and endangered species of animals* 1 (Krasnoyarsk: Publishing house of Siberian Federal University)
[16] *The Red Book of the Republic of Tyva (animals, plants and mushrooms)* 2018 (Kyzyl)
[17] Pinyasova E V, Zlotnikova T V and Geld T A 2014 Population status *Larus argentatus*
mongolicus Sushkin, 1925 (Aves; Laridae) of Koibal steppe region (South Minusinsk basin)  
Ecology of Southern Siberia and adjacent territories 18(1) 113-4

[18] Geld T A, Zlotnikova T V and Pinyasova E V 2015 Great cormorant Phalacrocorax carbo (Linnaeus, 1758) - a new breeding species of the Minusinsk basin Ecological monitoring and biodiversity 3 62-7

[19] Melnik O N, Geld T A, and Zlotnikova T V 2015 Spatial-territorial distribution and nesting biology of Recurvirostra avosetta Linnaeus, 1758 and Larus ichthyaetus Pallas, 1773 (Aves, Charadriiformes) in the conditions of the southern part of Central Siberia Modern problems of science and education 3

[20] Geld T A and Zlotnikova T V 2016 Dynamics of abundance of Larus ichthyaetus Pallas, 1773 (Aves, Laridae) in “Tract Trekhozerki” Ecology of Southern Siberia and adjacent territories 20(1) 84-5

[21] Stepanyan L S 2003 Abstract of the ornithological fauna of Russia and adjacent territories (within the borders of the USSR as a historical area) (M.: Academic book)

[22] Liebers D, Helbig A J and Knijff P De 2001 Genetic differentiation and phylogeography of gulls in the Larus cachinnans–fuscus group (Aves: Charadriiformes) Molecular Ecology 10 2447-62 doi.org/10.1046/j.0962-1083.2001.01370.x

[23] Liebers D and Helbig A J 2002 Phylogeography and colonization history of Lesser Black-backed Gulls (Larus fuscus) as revealed by mtDNA sequences Journal of Evolutionary Biology 15(6) 1021-33

[24] Liebers D, Helbig A J and Knijff P De 2001 Genetic differentiation and phylogeography of gulls in the Larus cachinnans – fuscus group (Aves: Charadriiformes) Molecular Ecology 10 2447-62 doi.org/10.1046/j.0962-1083.2001.01370.x

[25] Firsova L V 2013 Geographical variation, system and evolution of silver gulls and laughter of the complex Larus argentatus Pontoppidan, 1753 - Larus cachinnans Pallas, 1811 Russian Ornithological Journal 22(867) 941-79

[26] Redkin Y A, Arkhipov V U, Volkov S V, Mosalov A A and Koblik E A 2015 View or not view? Controversial taxonomic interpretations of birds in Northern Eurasia Russian Ornithological Journal 24(1237) 141-71

[27] Baranov A A and Melnik O N 2009 Black-headed laughter of Larus ichthyaetus Pall. and silver gull Larus argentatus mongolicus Sushkin in the Altai-Sayan ecoregion Modern problems of ornithology in Siberia and Central Asia 38-45

[28] US Geological Survey Remote Sensing Data Download Service 2019 Retrieved from http://earthexplorer.usgs.gov

[29] Chivilev S M, Lyakhova V A, Korneva S V, Matveev I V, Solo dov A A, Prozorova V M and Pehelintsev V G 2004 Space imagery processing algorithm for assessing the state of the environment Proceedings of the IV International Symposium “Environmental Monitoring and Rehabilitation” (Tomsk) pp 81-2

[30] Prokofiev S M 1991 On the biology of saj and black-headed laughter in the Minusinsk basin Ornithological problems of Siberia 155-7