


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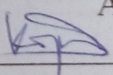
SOHAM RAY

CERTAIN ASPECTS OF AQUATIC AND SEMI-AQUATIC BIRD'S BIOLOGY
IN WESTERN SIBERIA

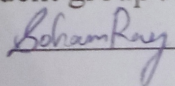
MASTER'S THESIS

For qualification of master's degree of Biology
According to the basic educational program of masters
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ABSTRACT

In this multi-fronted study we have presented the different aspects of biology of water and semi-aquatic birds in West Siberia at three levels of biodiversity. Genetic level - represented by study of Bean goose complex and their genetic diversity; Species level - study of two closely related colonial species of Sand Martins; Ecosystem level - study of biodiversity of waterbirds and their dynamics in Kolarovo wetlands (important ornithological territory). Phylogenetic analysis of mtDNA CR region of one of the samples of Bean Goose showed the presence of *A. f. middendorffii*'s in the tundra zone of West Siberia. By the statistical analysis of the nest hole positions of twin species of *R. diluta* and *R. riparia* we can understand that there is competition even after coexistence between them. While nesting in a mixed colony exhibits coexistence, but the statistical significance in the nest height difference also exhibits a sign of competition. By the observation and comparative analysis from previous decade's records, a decrease in the abundance and diversity of bird species were observed in almost all taxonomic groups.

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INTRODUCTION

Though the avifaunal biodiversity of Siberia is well studied [Gyngazov, Milovidov, 1977; Ryabitsev, 2014], there are still some unsolved problems which makes the study of birds relevant. For example, some territories are still not well observed and hence the composition of birds and ranges of many species need to re-examined. Another modern problem is climate change which adds to alteration in the biodiversity of birds. The use of genetic methods during the last few decades opened the possibility to re-examine the phylogenetic classifications leading to division and probable 'new' species. In Russia, there are about 800 species of birds. According to Koblik et al. [2006] there are 789 species of birds, but in other book there are 808 species of recorded avifauna in which there are 68 globally threatened species [Clements, 2007]. There are two species which are recently declared extinct - Jankowski's Bunting (*Emberiza jankowskii*) [www.birdguides.com] and Spectacled Cormorant (*Phalacrocorax perspicillatus*) [Watanabe, 2018]. Another species Slender-billed curlew (*Numenius tenuirostris*) which previously was known as nesting in West Siberia and was last observed on 2004 in Europe [Zhud, 2005] may also be extinct in the wild. Western Siberia presents us with many research interests like the nesting of migratory species, the migratory stopovers, the phylogenetic relations between subspecies, the unique seasonal changes and research for the diversity of avifauna. In this study we have presented the different aspects of biology of water and semi-aquatic birds in West Siberia at three levels of biodiversity. Genetic level – represented by study of Bean goose complex and their genetic diversity; Species level – study of two closely related colonial species of Sand Martins; Ecosystem level – study of biodiversity of waterbirds in Kolarovo wetlands – important regional ornithological territory. These three levels work synchronously to sustain the complexity of life on Earth and thus it becomes important to conserve biodiversity

holistically instead of focusing on a single species. Since no organism exists in isolation, thus not only conservation should be focused on the survival of a single endangered species from extinction, but we should also consider the habitat in which they live for conservation too.

Genetic diversity is the variety of genetic characteristics within a species. Each species is made up of individuals that have their own particular genetic identity. This means a species may have different populations, each having different genetic compositions. To conserve genetic diversity, different populations of a species must be conserved. Genes are the basic units of all life on Earth. They are responsible for both the similarities and the differences between organisms. Not all groups of animals have the same degree of genetic diversity. For example, the Spectacled Cormorant (*Phalacrocorax perspicillatus*) come from an evolutionary line which are genetically very similar to other cormorants. So, it can be believed that we should concentrate on saving more genetically diverse groups, such as phalacrocoracidae which includes 40 species of aquatic birds such as cormorants and shags [Kennedy, 2014]. If we lose one species of phalacrocoracidae, we lose a substantial genetic resource. Several species of phalacrocoracidae are endangered and at least one, the Spectacled Cormorant (*Phalacrocorax perspicillatus*) has disappeared forever [Watanabe, 2018]. Assessment of genetic diversity is important as a basis for the sustainability of the existence of populations. More genetically diverse populations have more adaptive capabilities in a changing environment.

Species diversity is the variety of species within a habitat or a region. Some habitats, such as rainforests and coral reefs, have many species. Others, such as deserts or a polluted stream, have fewer. In Russia, more than 80% of avifaunal species are migratory, which means that they also live outside Russia. Nevertheless, they play a very important role in ecosystem during nesting and migration period. Composition of species of birds of Tomsk region is counted about 340 [Ryabitsev et al., 2001]. Some of the species such as *Riparia diluta* were described as new species and were separated from the previously known species such as *Riparia riparia*. Now these closely related

species coexist together as twin-species in the same territory. Studying of twin-species is of great interest in the aspects of microevolution, competition and colonialism. The comparative biology of these species will help us in understanding the divergence from its twin-species.

Ecosystem diversity is the variety of ecosystems in a given place. An ecosystem is a community of organisms and their physical environment interacting together. An ecosystem can cover a large area, such as a whole forest, or a small area, such as a pond. An ecosystem is a community of organisms and their physical environment interacting together. An ecosystem may be as large as the Tundra or as small as the back of a spider crab's shell, which provides a home for plants and other animals, such as sponges, algae and worms. In present study the Kolarovo lake system was under observation. This system is an important territory for birds during migration and nesting. About 150 species of birds can be seen in these lakes and half of them related with water. This territory now is under protection as a monument of nature. It has scientific, aesthetic, educational value. During more than 20 years, ornithologists from Tomsk monitored the migration of birds for estimation of sustainability of resources of wildfowl for hunting and conservation.

The main aim of the research was to study different aspects of biology of water and semi-aquatic birds in West Siberia at three levels of biodiversity. Specifically, we have focused on 3 tasks:

- (i). On the basis of genetic methods to identify the subspecies composition of Bean Goose in the north of West Siberia (Yamalo-Nenetskiy autonomous okrug).
- (ii). Research the aspect of coexistence of *Riparia riparia* and *Riparia diluta* as a twin species by studying nest hole positions in a mixed colony on the bank of Tom river.
- (iii). Study the composition of water and semi-aquatic birds and their dynamics in the important ornithological territory of Kolarovo wetlands.

1 MATERIALS AND METHODS

1.1 Study of genetic diversity of Bean Goose

We have conducted our study of genetic diversity with the bean geese samples (n=3) collected from Yamalo-Nenetskiy autonomous okrug. Samples (cut heads) of the bean goose were given by the hunters of this region. Our aim is to contribute to the knowledge about composition of the subspecies of bean geese habitat in the North of West Siberia. Muscles from the necks were used as the material for DNA extraction followed by phylogenetic analysis. We conducted phylogenetic analysis based on the variability of the control region (CR) of mitochondrial DNA. Special studies have shown that the use of DNA isolated from feathers, unlike DNA isolated from blood, muscles and other tissues, significantly reduces the likelihood of amplification of nuclear copies of mitochondrial genes (NUMT) characteristic of goose [Ruokonen et al., 2000]. To avoid amplification of NUMT we used specially tested primers (Table 1) which better fit to mtDNA. The PCR conditions are taken from the work of Ruokonen et al. [2000].

Table 1 – Primers used in work for amplification of part of the CR mtDNA

Name	Nucleotide sequence	Specificity
L334	TCAACATGAATGCTCTAGGACT	mtDNA
H466	ATTAGTCGTACTCCTCACGTGAAA	nu-DNA, mtDNA

Reaction conditions: initial denaturation 1 minute – 94 ° C, then 30 cycles: denaturation 94 ° C – 30 seconds, annealing 53-63 ° C – 1 minute duration, elongation 72 ° C – 1 minute, and the final stage of synthesis – 2 minutes at 72 ° C. PCR results were visualized using GelDoc BioRad in an agarose 1% gel. Sequencing was carried out on the basis of Scientific Center "Syntol", Moscow.

The obtained sequences were aligned in the BioEdit 5.0.9 program. This procedure is necessary to identify substitutions, insertions and deletions that took place in the evolutionary history of the analyzed sequence group. Sequence alignment is aimed at

identifying homologous positions of the analyzed sequences, establishing the most probable, i.e. requiring the least number of evolutionary events, scenario for the evolution of the analyzed group [Lukashov, 2009].

Heads, especially bills were used as the material for morphological analysis. For morphology of subspecies identification of Bean goose the length and height of bill are usually used. We used scale and hand calliper for study of morphology.

1.2 Study of nest hole position of two colonial species of Sand Martins

This work is based on materials collected in the period June–July 2021 on the Tom River, where the mixed colony of martins was surveyed (Fig. 1). This is the biggest colony with about 6300 nest holes (2021) among many colonies along the banks of the Tom river. It is located on the left bank of the Tom River opposite to the southern part of the city of Tomsk in the vicinity of Sennaya Kurya ($56^{\circ}26' 31.64''\text{N}$ $84^{\circ}57' 35.17''\text{E}$).



Figure 1: Layout of sand martin colony on the Tom River

To establish the species among the twin species of birds, they were caught with mist nets installed in front of the nest burrows, followed by banding. For accurate

identification of species, in addition to size, attention was paid to: the color of the plumage of the upper body and the thoracic sling; the severity of the borders of the thoracic sling, ear and throat coverts (the throat of *R. riparia* is pure white, in *R. diluta* – with a grayish tinge). According to a number of authors [Goroshko, 1993; Loskot, 2006; Evtikhova & Savchenko, 2014], the plumage of the tarsus (fully feathered in *R. diluta* and represented in *R. riparia* by a tuft of feathers at the base of the hind finger) are important signs that are important in species identification; the color of the paws; the color of the reduced first flight feather (in the coastal one it practically does not differ from the rest of the flight feathers, and in the pale swallow it is light and contrasts well with them). We also took into account and checked these signs. To confirm the facts of the differences, photographs were taken (Fig. 2).



Figure 2: Pale martin (left) and sand martin (right)

To assess the nesting abundance, both species of sand martin nests were counted. Survey of the total colony was done with the allocation of residential and non-residential nests. Residential nests were burrows with traces of activity in them and/or the presence of nest materials or clutches of eggs inside. Non-residential were burrows where no such activities of birds were observed.

Two ZVE 150SD videoscopes were used to identify the activity and presence of birds inside the burrows. At the Sennaya Kurya site, the analysis was carried out on the basis of data on number of active residential burrows of sand martins.

To reveal the structure of the colony, photographs of fragments of the colony overlapping with each other were made and were printed out. The chosen fragment contained 334 nest of both species in total. Then the birds were observed visually and also using binoculars, paying attention to the morphological differences in coloration during departure or approach to the burrow or when individuals were near the burrow. Each fragment in a single photograph was observed by 3 persons for 30 minutes (Fig. 3).



Figure 3: Sand martin burrows in a sub fragment of the studied colony



Figure 4: Panoramic structure of the total colony fragment

The distance of each nest from a common boundary was measured using the same software GIMP. To find out whether the nest holes of the two species were stratified along vertical horizons, we measured the distance from each nest to the line of the conditional lower horizon on the photograph of the colony, which allowed us to determine any differences between the species for nest height. As a result, a ready-made panoramic photo-scheme of the structure of the colony was obtained (Fig. 4). The burrows of sand martin were marked in green and the burrows of pale martin were marked in orange in the diagram. At the end of the observations, the identified nests were digitally transferred to the panoramic scheme of the colony using GIMP a photo editing software (Fig. 5).

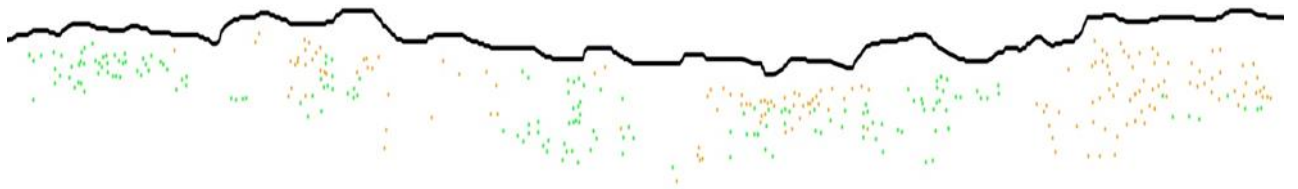


Figure 5: Digitalized spatial structure of the total colony fragment consisting of about 334 residential nests

In the chosen fragment we selected mono and mixed sub fragments of the colony in which the distance from the lower horizon to the nest holes of each species were measured separately. We observed 3 mono sub fragments of *R. riparia*, 2 mono sub fragments of *R. diluta* and 3 mixed sub fragments of both species coexisting in this colony. There were 163 nest holes in the mixed sub fragments (95 *R. diluta*+68 *R. riparia*), 108 nest holes in *R. riparia* and 63 nest holes in *R. diluta* mono sub fragments.

1.3 Study of Kolarovo lakes

The natural monument ‘Kolarovo Wetlands named after S.S. Moskvitin’ is a system of oxbow lakes on the floodplain of the Tom River, situated on its right bank and separated from the river by the embankment of the Tomsk –Yarskoye highway (Fig. 6). To the north, the village of Kolarovo (Spasskoye) adjoins the reservoirs, which affects the anthropogenic load on this ecosystem (amateur fishing, haymaking, the presence of dogs). Located just 15 km south of Tomsk, the lakes attract citizens as a place of rest, picnic and bonfire. This lake system received the status of a natural monument of regional significance in 2015 (Resolution of the Tomsk Region Administration No. 5a dated 14.01.2015). The coordinates of the western end of the lake starts from 56.33 N, 84.94 E to the south-eastern end at 56.32 N, 84.96 E.

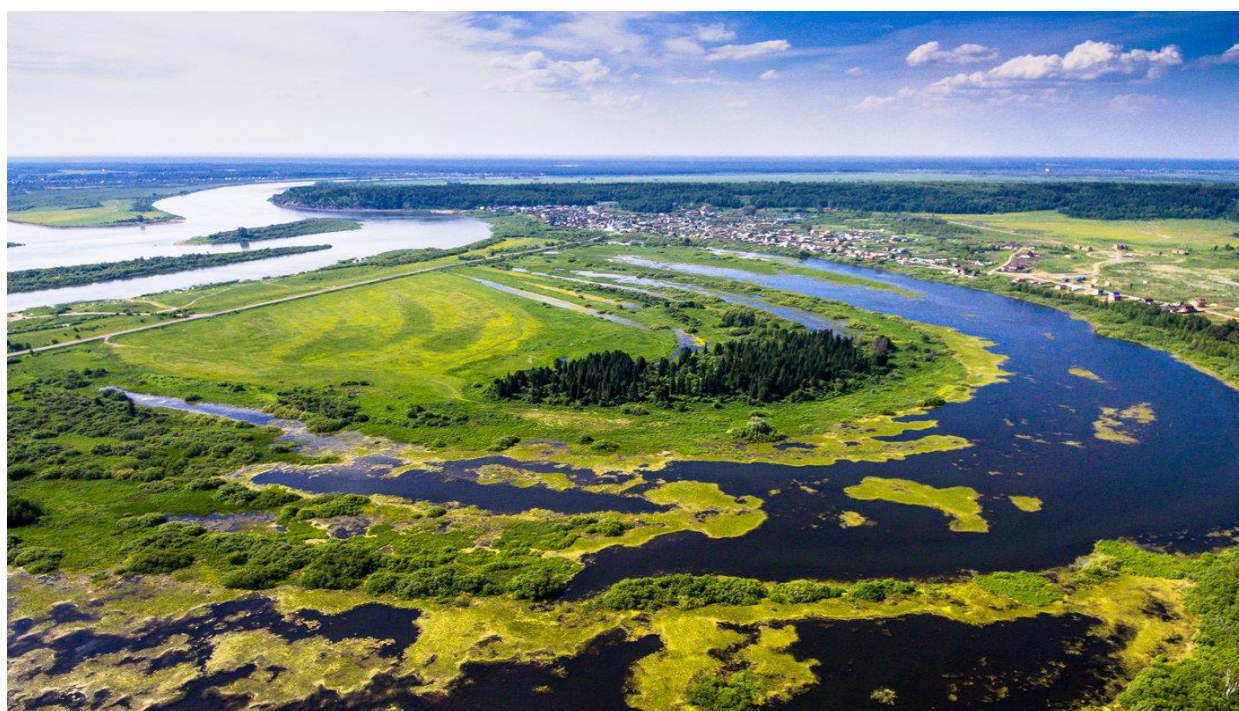


Figure 6: Kolarovo wetlands named after S.S. Moskvitin (www.nat-geo.ru)

The observations took place in two stages: 1) assessment of spring visible migration (daily morning 1-2 hour observations of the visible flight from the observation post and on the registration site (Fig. 7) with an area of about 1 km², April–May) and 2) areal counts of the summer-autumn bird population conducted on the same territory with a frequency of 1 every 7-10 days from mid-July – until the middle of October.

Different species of aquatic birds were registered in spring season. However, it is important to take into account not only the number of species encountered, but also their abundance, since biodiversity takes this indicator into account, and for assessing the state of the resource of aquatic birds, abundance indicators may be even more important.



Figure 7: Field trip at the Kolarovo lake with my supervisor.

In total, 50 species of aquatic birds were registered in spring and 16 during summer counting.

2. Bean goose complex and their genetic complexity

2.1 Genetic study of Bean goose (review)

The taxonomic status of Bean goose (*Anser fabalis*) is still not precisely defined and taxonomists have not had a consensus on the structure and volume of the species for a long time, not to mention a more fractional structuring. In various sources [Ruokonen et al., 2008], the number of described species ranges from one to four and there are up to seven subspecies [Naumann, 1842; Alpheraky, 1905; Hartert, 1914; Buturlin, 1935; Coombes, 1951; Delacour, 1951; Bauer, 1968; Cramp & Simmons, 1977; Sangster & Oreel, 1996; Mooij et al. 1999]. Most researchers have recognized the existence of two monotypic species: the short-billed bean goose *Anser brachyrhynchus* and the bean goose *Anser fabalis* proper.

Research to divide the species into sub-species are carried on for more than a century [Mooij et al.1999; Ruokonen et al. 2008]. There are 4 subspecies of *A. fabalis* recognized in Russia now (Fig. 8): western tundra (*A. f. rossicus*), western forest (*A. f. fabalis*), eastern tundra (*A. f. serralensis*), and eastern taiga (*A. f. middendorffii*). The western tundra bean goose nests in the tundras of Russia from the Kola Peninsula to Taimyr, where it is replaced by the eastern tundra common to Chukotka. The western taiga bean goose nests sporadically in the forest zone from Scandinavia to the Yenisei, while the eastern taiga bean is distributed in patches from the Yenisei basin to Kamchatka and Chukotka in the north, and the Amur and Tuva in the south [Linkov, 2002]. The latter subspecies *A.f.middendorffii* is one of the rarest subspecies, the number of which is declining [Emelvanov, 2000] and requires close attention. For a long time, unfortunately, Bean goose were considered an inexhaustible resource, and it was not given due attention in scientific hunting studies [Linkov, 2012]. At the moment, in many regions of Siberia, this species or its subspecies are included in the Red Books (Kemerovo Region, Novosibirsk region, KhMAO, Krasnoyarsk Krai, etc.). Since there is a possibility that the migration of the subspecies *A.f.middendorffii*, which is small in number, passes through the territory of Western Siberia, its presence in this territory should be checked. Thanks to the works of M. Ruokonen et al. [2000; 2008],

which described the method of genetic assessment of the diversity of geese, as well as revealed the specificity of the eastern taiga Bean goose, it was decided to evaluate the diversity of Bean goose in Western Siberia and check for the presence of a rare subspecies *A.f.middendorffii*.

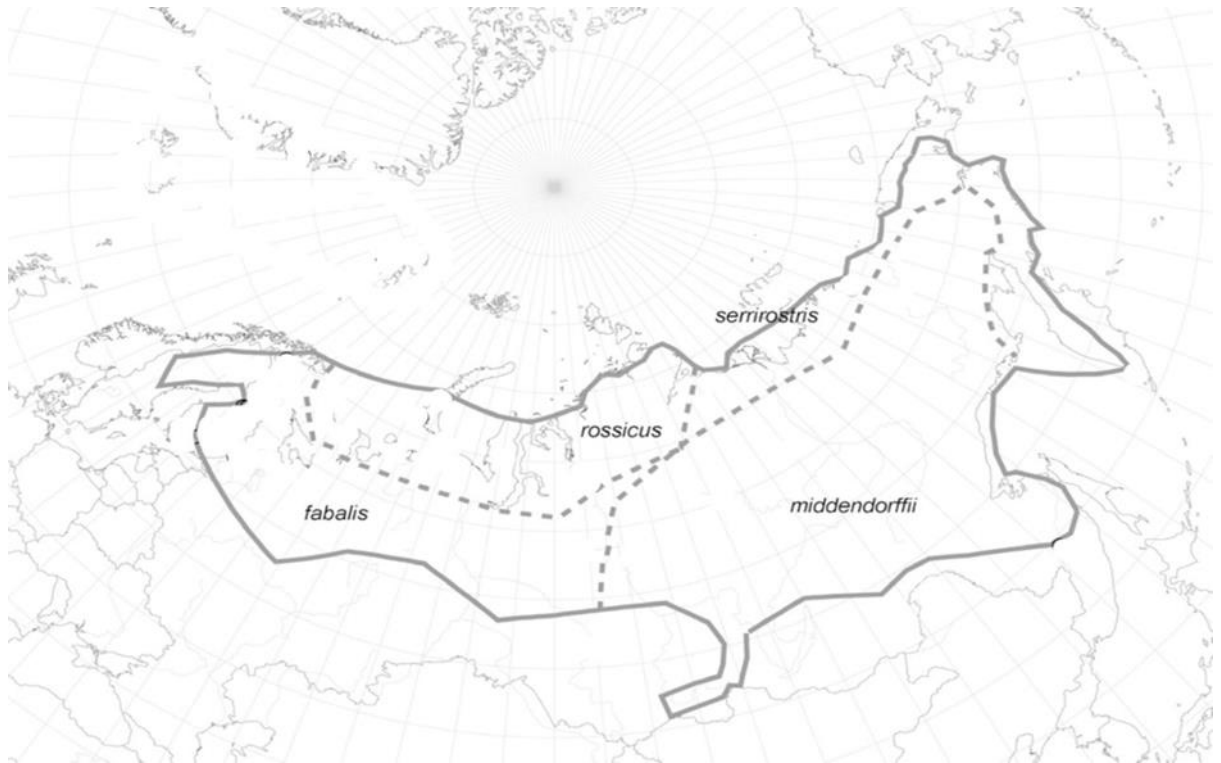
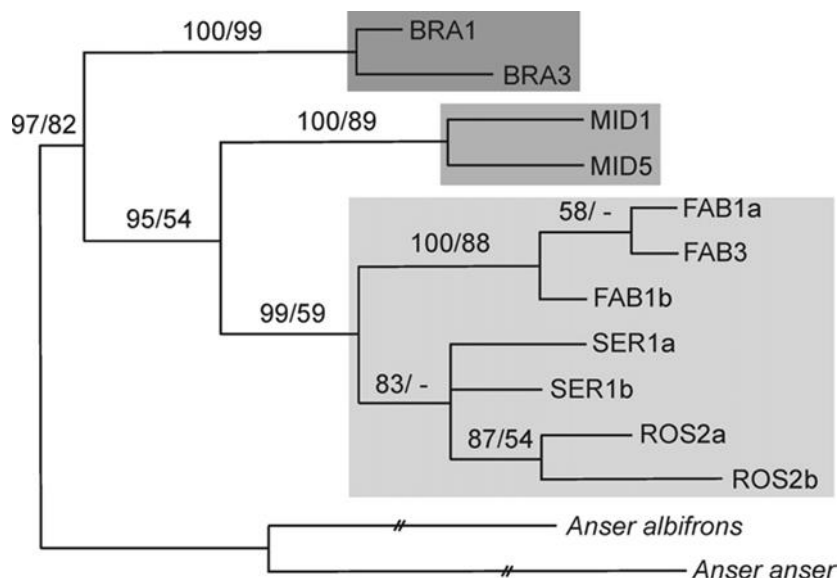


Figure 8: Nesting range of Bean goose subspecies [Ruokonen et al., 2008]

There are strong indications that the Bean Goose deserted a part of its former breeding range since the beginning of the 20th century, due to increased human activities in these areas. At present the world population of Bean Goose seems to be declining. Both the Eastern Palearctic and the taiga breeding population seems to show a declining trend. The need for absolute clarity in Bean goose complex also arises in preventing them from further decline caused by widespread hunting practices in Eurasian regions including Yamalo-Nenetskiy autonomous okrug and Tomsk oblast.

According to modern data (Fig. 9), based on the genetic analysis of the mtDNA D-loop, a phylogenetic tree has been constructed that displays the evolutionary relationships of Bean goose. Thus, it is shown that Bean goose included three

subspecies: *A. f. fabalis*, *A. f. rossicus* and *A. f. serrirostris*, while *A. f. middendorffii* formed a separate clade, with a genetic distance allowing it to be attributed to a separate species [Ruokonen et al., 2008; Honka et al., 2017]. Nevertheless in most of the studies researchers suggest that *A. f. middendorffii* is a subspecies of the Bean goose.



BRA – *A. brachyrhynchus*, MID – *A. f. middendorffii*, FAB – *A. f. fabalis*, SER – *A. f. serrirostris*, ROS – *A. f. rossicus*. The white-fronted goose (*A. albifrons*) and gray goose (*A. anser*) were taken as an out-group

Figure 9: Phylogenetic tree of subspecies of Bean goose *Anser fabalis* based on mtDNA D-loop [Ruokonen et al., 2008]

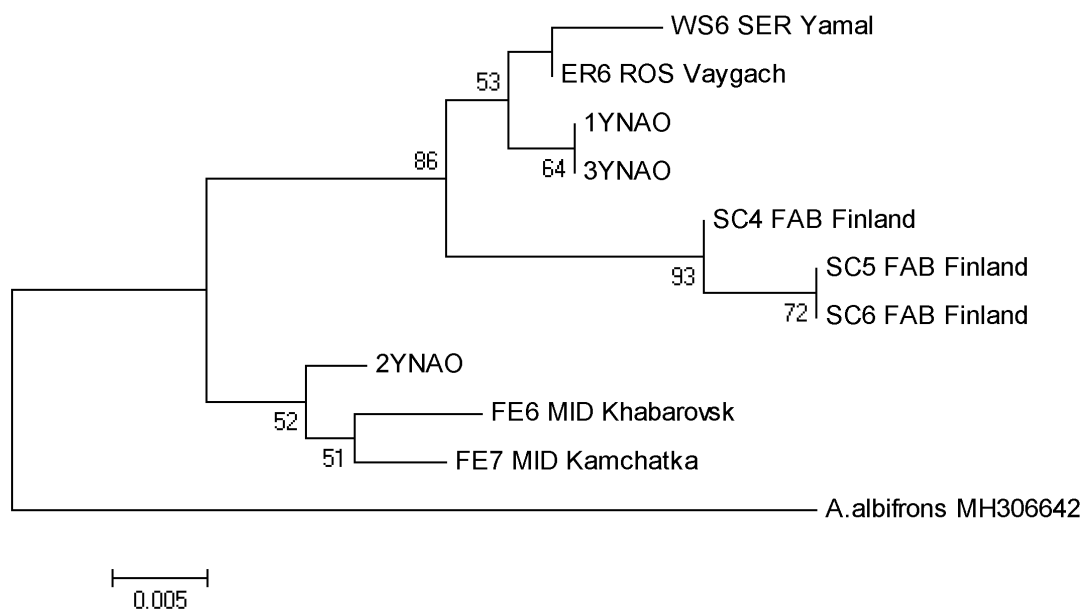
2.2 Genetic diversity of Bean goose in north part of Western Siberia (YNAO)

It is considered that between western (*Anser fabalis rossicus* and *A. f. fabalis*) and eastern subspecies (*A. f. middendorffii*, *A. f. serrirostris*) of the bean goose *Anser fabalis* there is a border that runs along the Yenisei River. Thus, according to these data only the western subspecies occurs in Western Siberia. Nevertheless, as early as 1898 G.E. Ioganzen assumed that *A. f. middendorffii* can migrate via the south of West Siberia. Later, H. Johansen and J. Delacour described *A. f. johanseni* – the form of bean goose which was typical for southern West Siberia. Finally, M. Ruokonen with colleagues showed that it genetically identical to *A. f. middendorffii*. In 2009–2017

researchers from Tomsk state university analyzed 40 samples of bean geese from Tomsk region (taiga zone of West Siberia) and 22 from Altai Krai (steppe zone of West Siberia), which were shot by hunters in spring. With the aim to determine the subspecies identity of these geese, they analyzed d-loop sequences of the mtDNA. Surprisingly, among all individuals 45 % in Tomsk region and 59,1 % in Altai Krai proved to belong to *A.f.middendorffii*. We suggest that the western border of the range of the *A.f.middendorffii* may have shifted from Yenisei up to Ob river. Another possible explanation of this result is that we can turn back to idea of validity *A.f.johanseni* which genetically is closely related with *A.f.middendorffii*. The subspecies 'johanseni' was described for West Siberia by Delacour (1953) but now their validity is not recognized. Despite the urgent need of conservation of the taiga form subspecies, it is under severe hunting pressure in Tomsk region and Altai Krai. Obtained data is a serious argument to stop hunting of geese in the Western Siberia.

One of our task was to genetically analyse 3 bird heads collected from the hunters to further understand the subspecies composition of YNAO.

Among the 3 individuals on the phylogenetic tree two were grouped with tundra subspecies (*A.f. rossicus* and *A.f. serrirostris*) and one was placed in the clade included subspecies *A.f. middendorffii*. This result can indicates that tundra zone of West Siberia should be included in range of *A.f. middendorffii*. Another explanation is that West Siberia is the zone of hybridization between eastern taiga and western forest subspecies and bird which carried this haplotype is of hybrid origin. The last fact is more credible, because the bill length of this individual (64.1 mm) is in the range of the minimal value, which is known for *A.f. middendorffii*.



SER – *A.f. serrirostris*, ROS – *A.f. rossicus*, FAB – *A.f. fabalis*, MID – *A.f. middendorffii* (Data from GenBank) YNAO – Yamalo-Nenetskiy autonomous okrug (Our samples).

Figure 10: Phylogenetic tree of *Anser fabalis* based on variability of CR of mtDNA (NJ, Tamura-Nei evolutionary model)

3 Two closely related species of sand martins (*Riparia riparia* and *R. diluta*) and study of their biology

3.1 The separation of two species of Sand martins from genus *Riparia* and perspectives of their studying

At the end of the 20th century on the basis of morphological and ecological features of the subspecies *Riparia riparia diluta*, a number of authors proposed to assign the status of an independent species [Gavrilov & Savchenko, 1991; Goroshko, 1993]. Now the pale martin *R. diluta* Sharpe et Wyatt, 1893 and the sand martin *R. riparia* L., 1758 are independent species. The reliability of separation of the race into a full species has recently been confirmed using molecular genetics [Pavlova et al. 2008], although the Sand Martin (*Riparia riparia*) and Pale Sand Martin (*Riparia diluta*) have much in common. The study of the biology of these two species is of great interest both from the point of view of biodiversity, and in relation to such general biological problems as mechanisms of microevolution, colonialism and interspecies competition. The search for differences is particularly relevant in species that live together in mixed colonies such as Sand and Pale Sand Martins, which is observed, for example, in western and central Siberia [Gryaznova & Savchenko, 2017].

The distribution of martins of the genus *Riparia* in the Palearctic during the breeding period is actually not continuous, as it has long been assumed and displayed on range maps. In some areas, both species of martins are completely absent from nesting, in some, sometimes extensive, spaces only *R. diluta* nests and *R. riparia* is completely absent. The figure shows the distribution of swallows of both species (Fig. 11).

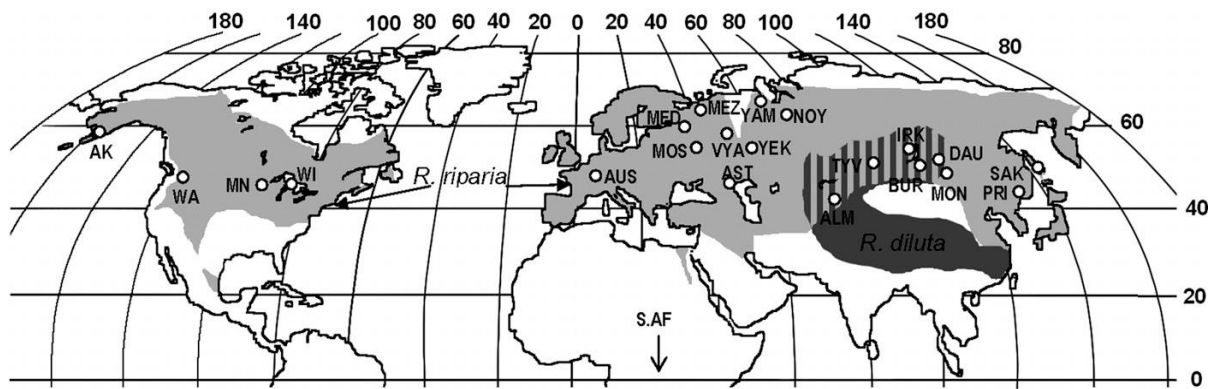


Figure 11: Distribution of swallows *R. riparia* and *R. diluta* [Pavlova et al., 2008].

Note – The distribution of *R. riparia* is light gray; *R. diluta* is dark gray.

In Russia both species meet together in some parts of Central and West Siberia. Pale martin was found in the Novosibirsk region in mixed colonies with a Sand martin [Zhukov et al., 2009]. For the Kemerovo region, it was shown that both species nest from 80-s of the 20th century and at present, the sand martin and pale martin live together on the territory [Kovalevsky et al., 2012].

Sand martins are typical colonial-nesting birds. A colony is a relatively dense, spatially isolated settlement of animals [Kharitonov, 2011]. In other words, a colony is a type of nesting settlement where the distance between the nests is small and comparable to the size of the nests themselves (a concentrated nesting settlement of birds) [Zubakin et al., 1983].

Mixed-species colonies of birds are a common phenomenon, typical for herons, gulls, terns and other birds [Burger 1979, Götmark 1982, Yorio & Quintana 1997, Simeone & Schlatter 1998]. On the one hand, these colonies solve the problem of a shortage of nesting sites [Lack 1968], on the other, they enable collective defense against predators or the protection of one species by another, more aggressive, species in the colony [Hilden 1965, Erwin 1979, Götmark & Ahlund 1988]

The colonial way of life has its minuses and pluses. Thus, the characteristic disadvantages in the colony are competition for nesting sites, nest-building material, partners. Increased transmission of ectoparasites between group members is also characteristic. In turn, the colonial lifestyle has benefits compared to solitary nesting in protection from predators. They are less likely to attack a group than a single

individual. When a predator approaches, the swallows together begin to emit loud cries, thereby warning others about the danger. Also, the advantage of the colonial lifestyle is sociality in foraging, since it is easier and faster to search for insects in a group than alone [Hoogland & Sherman, 1976; Brown & Hoogland, 1986].

3.2 The position of nest holes of two species of Sand martins in mixed colony

During our study we revealed the positioning of nests of the two species in mixed-species colonies by dividing from the whole colony of 334 residential nests (control section of the colony). The colony consisted of the following sub fragments - 3 mono sub fragments of *Riparia riparia*, 2 mono sub fragments of *Riparia diluta* and 3 mixed sub fragments of both species coexisting in this colony. There were 163 nest holes in the mixed sub fragments (95 *R. diluta*+68 *R. riparia*), 108 nest holes in *R. riparia* and 63 nest holes in *R. diluta* mono sub fragments. Before nesting began, we monitored the date of arrival of each species, and concluded that the *Riparia diluta* arrived approximately a week earlier than the *Riparia riparia* [Scherbakova et al. 2020]. In the study section of the colony, the Sand Martin was the more common species with 52.6% of nests compared to the Pale Sand Martin composed of 47.3% of nests. This proportion does not necessarily reflect the actual number of these species in the area, for example, estimates based on mist-net captures suggest that in previous years 81.1% of adults were Pale Sand Martin.

The Pale Sand Martins were visually seen to be more active as they were taking flights more frequently and directly entering the burrows unlike the Sand Martins who were observed to be resting on the entrance of the burrows for quite a few seconds (30 seconds to 10 minutes) as in fig. 12. This may be due to the slightly smaller size of Pale Sand Martins. Although there were no shortage of free nesting burrows, they tended to nest close to one another in mixed colonies leaving a significant part of the cliffs in the colony unoccupied. The observed coexistence may be associated with the benefit of joint protection against predators like the black kite (*Milvus migrans*),

hooded crow (*Corvus cornix*), Eurasian magpie (*Pica pica*) and Eurasian Hobby (*Falco subbuteo*) as observed in this location. Both the species of martins also identically manifested themselves during flights as a form of cooperative mobbing. The effectiveness of such protection also depends on the size of the colony as shown in other studies [Hoogland, Sherman 1976]. The fact that no pair mixing or interbreeding was observed in the colony, can largely be explained by the difference in their arrival dates. The Pale Sand Martins select nest sites earlier than the Sand Martin due to an earlier arrival, although both species start laying eggs simultaneously. Thus, despite the significant similarity in the biology and similarity in the reproductive period in these twin species, *Riparia riparia* and *Riparia diluta* were seen nesting separately without forming mixed pairs, which serves as a strong indication of their further evolutionary differentiation from the common *Riparia riparia* and *Riparia riparia diluta*.



Figure 12: Sand Martins (*Riparia riparia*) resting on the entrance of the nest burrows

We measured the height of each nest from a common boundary using the same software GIMP. To find out whether the nest holes of the two species were stratified

along vertical horizons, we measured the distance from each nest to the line of the conditional lower horizon on the photograph of the colony, which allowed us to determine any differences between the species for nest height. We calculated the statistical mean of the height of nest holes from the horizon using the software Statistica. Then they were graphically compared with each other in box plots where square dots represented means, boxes represented standard error (SE) and whiskers around boxes represented $1.96 \times \text{SE}$.

The colony structure showed a clear differentiation in the height of nests of the two martin species. The higher nest holes in the colony were typically occupied by Pale Sand Martins. When the average distances of nest position in *Riparia diluta* (180.62 cm) and *Riparia riparia* (157.69 cm) in mixed part of the colony were compared, the differences yielded statistical significance, $Z = 4.71$; $p = 0.00002$ (Fig. 13).

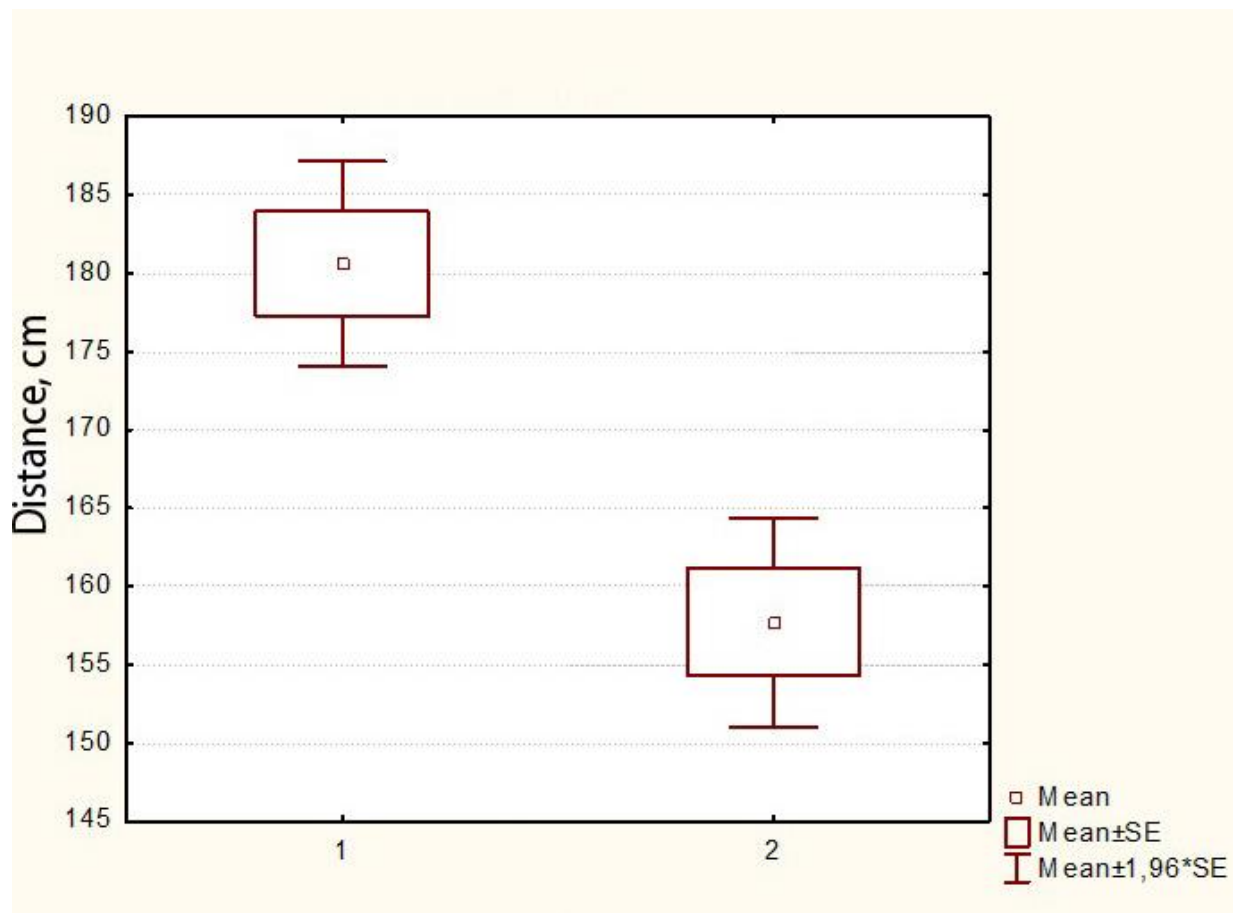


Figure 13: Comparison of average distances of nest position in *Riparia diluta* (1) and *Riparia riparia* (2) in mixed part of the colony. Square dots = means; boxes = standard error (SE); whiskers = $1.96 \times \text{SE}$. The differences were found to be statistically significant [$Z = 4.71$ $p = 0.00002$]

Average nest height comparison between *Riparia diluta* (179.77 cm) and *Riparia riparia* (169.06 cm) among all total of colony nests was also found to be statistically significant, $Z = - 2.66$, $P = 0.07$ (Fig. 14).

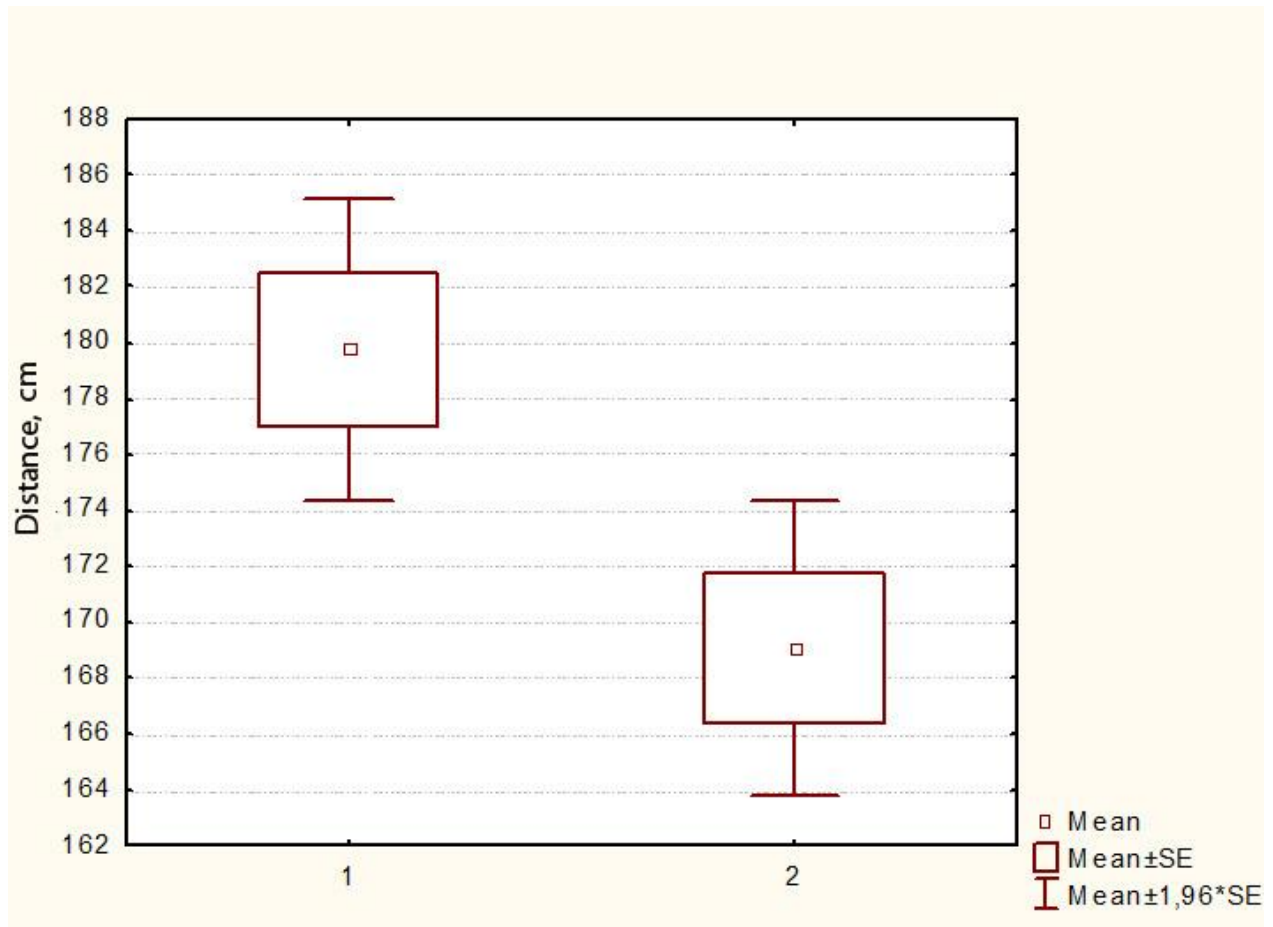


Figure 14: Comparison between *Riparia diluta* (1) and *Riparia riparia* (2) with average nest height of all nests in the colony. Square dots = means; boxes = standard error (SE); whiskers = $1.96 \times SE$. The differences were found to be statistically significant [$Z = - 2.66$; $P = 0.07$]

When the average distances of nest position in *Riparia diluta* (178.48 cm) in mono colony and (180.62 cm) in mixed colony were compared, the differences were not statistically significant, $Z = - 0.33$; $P = 0.73$ (Fig. 15). So, *R. diluta* always tend to nest in upper horizon of the colony.

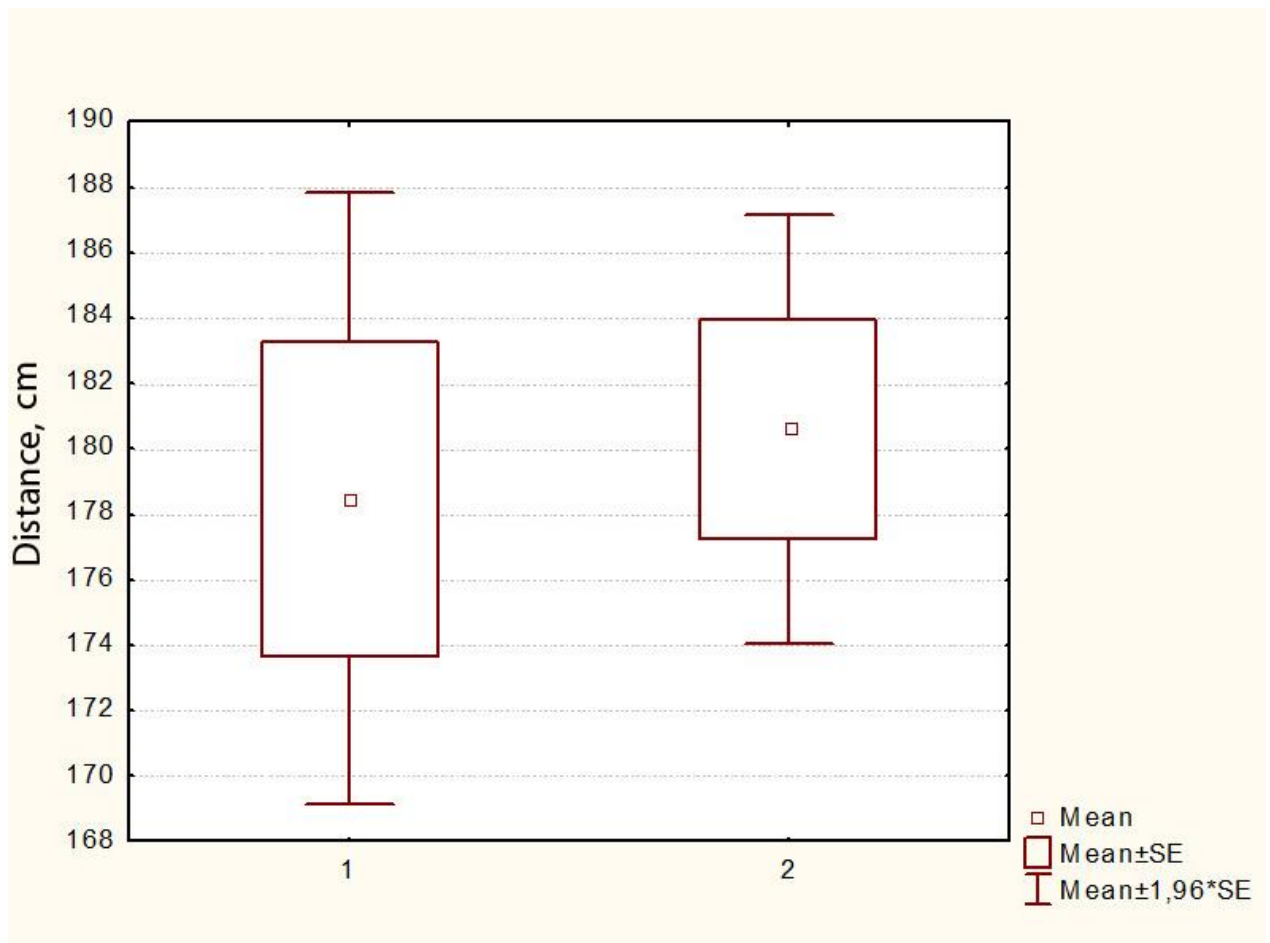


Figure 15: Comparison between *Riparia diluta* mono (1) and *Riparia diluta* (2) mixed part of the colony. Square dots = means; boxes = standard error (SE); whiskers = $1.96 \times SE$. The differences were found not to be statistically significant [$Z = -0.33$; $P = 0.73$]

Average nest height comparison between *Riparia diluta* (178.48 cm) and *Riparia riparia* (176.22 cm) in mono parts of the colony showed no statistical significance, $Z = 0.35$, $P = 0.72$ [Figure 16]. Lastly, when the average distances of nest position in *Riparia riparia* (176.22 cm) in mono colony and (157.69 cm) in mixed colony were compared, the differences yielded statistical significance, $Z = 3.64$; $P = 0.0027$ [Figure 17].

In the mono fragments of colonies both species occupied first of all the upper horizon. So, without the pressure of competition Sand Martin *R. riparia* prefer nest upper than in mixed fragment. But, in the mixed colonies the Sand Martins were pushed to fill in the lower portions while Pale Sand Martins occupied most of the upper and middle portions [Figure 5, 17].

Since, the Pale Sand Martins arrived at the breeding grounds approximately one week earlier than Sand Martins they were able to freely take the holes in the upper tier of the cliff face. The Pale Sand Martins took the holes remaining from the previous year or dug new holes around the old ones located in the upper horizon while spring floods usually caused the collapse of the lower cliff face along with the lower holes. This separation is an indicator of probable competition in between the two species.

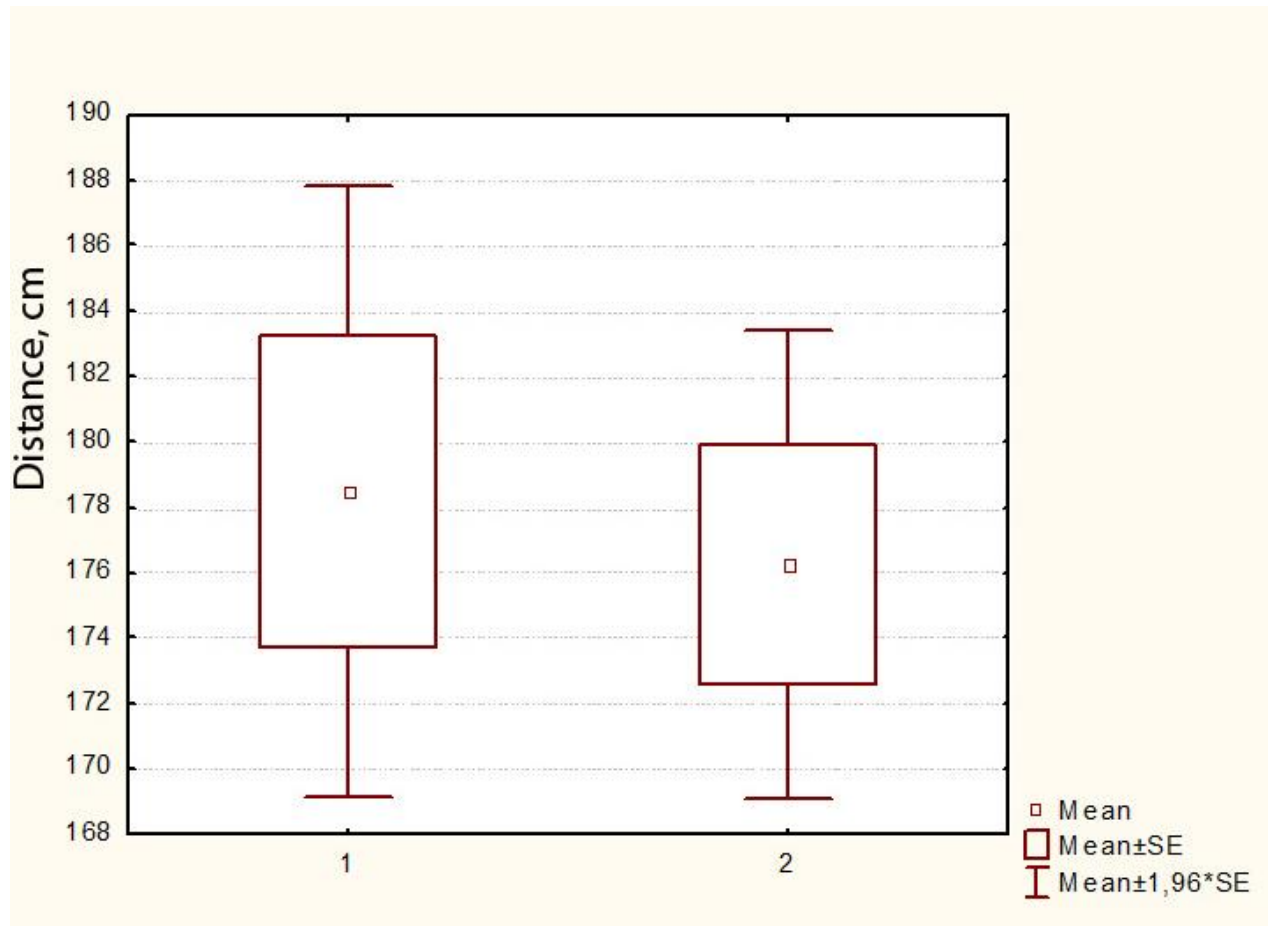


Figure 16: Comparison between *Riparia diluta* mono (1) and *Riparia riparia* mono (2) parts of the colony . Square dots = means; boxes = standard error (SE); whiskers = $1.96 \times SE$. The differences were found not to be statistically significant [$Z = 0.355$; $P = 0.722$]

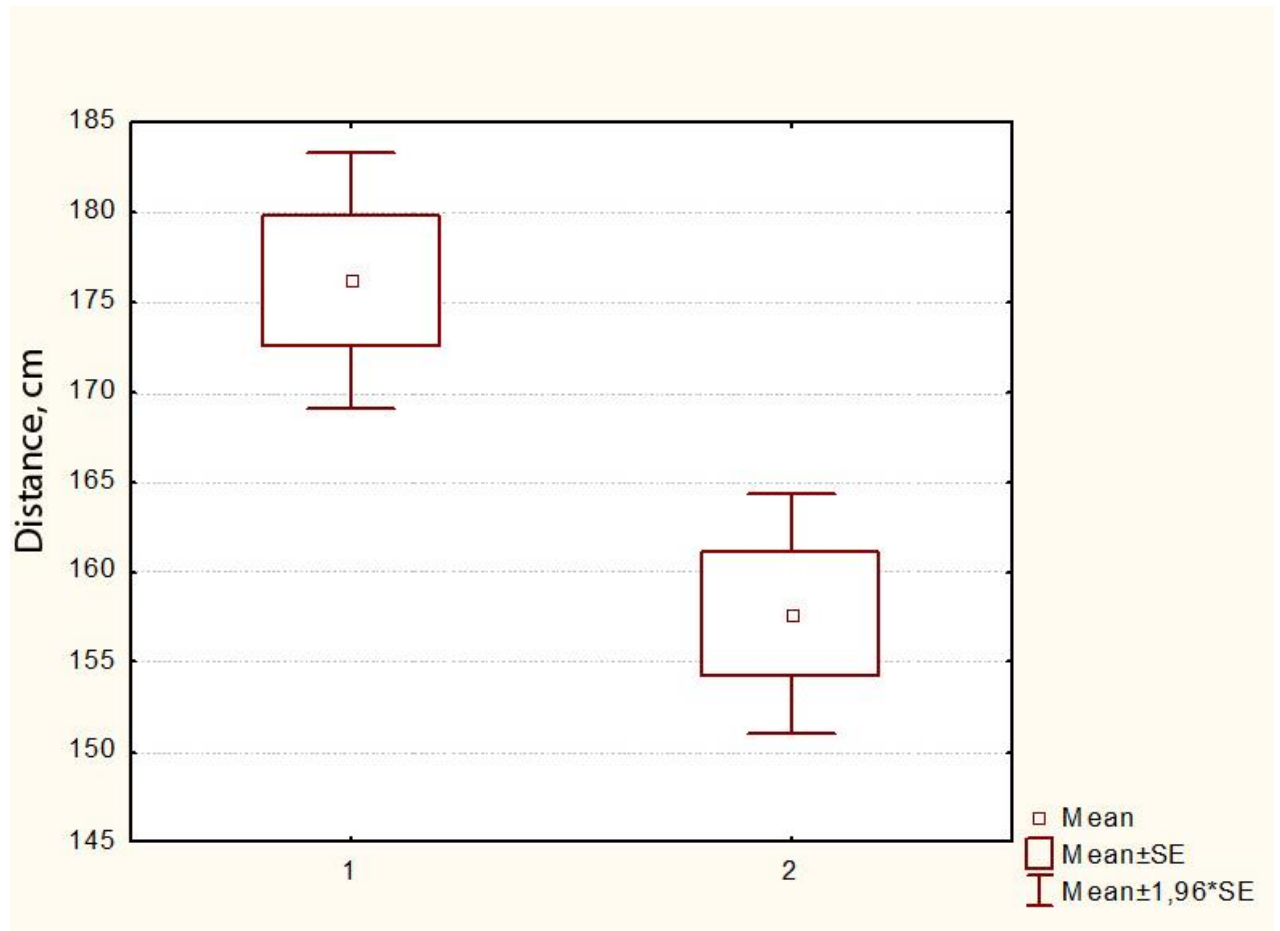


Figure 17: Comparison between *Riparia riparia* in mono (1) and mixed parts (2) of the colony. Square dots = means; boxes = standard error (SE); whiskers = 1.96 x SE. The differences were found to be statistically significant [$Z = 3.64$; $P = 0.0027$]

4 Kolarovo lakes as important wetland for water and semi-aquatic birds in the south of Tomsk region (West Siberia)

4.1 The characteristic of Kolarovo lakes for habitation of birds and composition of species

This was preceded by many years of ornithological studies of this territory, initiated by the director of the TSU Zoomuseum S.S. Moskvitin, whose name was given to this territory after his passing away in 2020. For the first time at the end of the XX century, he drew attention to the extraordinary diversity and concentration of aquatic birds on this system of reservoirs, not typical for other landscapes in the vicinity of Tomsk and, apparently, the entire subtaiga zone within the Tomsk region. Especially a lot of birds are recorded during the migration period, but the diversity at nesting is also quite high (Fig.17). In addition to reservoirs, the system includes a meadow area, as well as a remnant of coniferous forest (represented by fir, pine and cedar), which, on the one hand, increases the diversity of birds due to habitat diversity, on the other hand, provides protective (in particular, from wind) habitat conditions.

This lake system for TSU zoologists has become a long-term observation point for the migration of aquatic and near-water birds in the floodplain of the lower Tom, as well as a testing ground for studying their interannual and seasonal dynamics. It is the best suited for monitoring the state of the waterfowl resource, studying the phenological phases of the life cycles of birds, etc. However, due to natural reasons of a successional nature, the system is overgrown with aquatic and coastal vegetation, which reduces the area of the water mirror, the depth of reservoirs, and the duration of the existence of temporary reservoirs, which abounded in this system for the period of the beginning of observations, decreases. Unfortunately, bird sightings on this lake system in the last decade, for various reasons, have not been regular, but the one-time summer surveys conducted in recent years clearly indicated a decrease in the abundance and depletion of the diversity of birds of this lake system. In this connection, in 2021, an attempt was made to study in more detail the state of the bird population of this territory in order to identify the real picture and find out the reasons for the changes

taking place. Additional relevance to the study was given by changes in the Federal Law on Hunting (FZ-209 of 07/24/2009) and new hunting rules that came into force in 2021 and the subsequent changes in regional hunting rules in the Tomsk region (Governor's Resolution P08 of 1.02.2021), which doubled the hunting time for waterfowl, which is worrying. Therefore, the issue of monitoring the waterfowl resource and finding out its current state has become one of the key incentives to continue these studies on this territory significant in ornithological terms.



Figure 17: A poster board at the periphery of Kolarovo lake

4.2 Community of waterbirds of Kolarovo lakes

In total, 50 species of aquatic birds were observed during the springs of 2000 and 2021 (Table 2), representing the following orders: Podicipediformes (2), Anseriformes (16), Ciconiiformes (3), Gruiformes (5), Charadriiformes (24). This data contains approximately 70% of the species of these groups registered in this area for all previous year's research (71). The number of species encountered this year (50) is comparatively higher than the previous year's number of recorded species of 35–45 species per spring. The later can be explained mostly by a factor of coincidence, since among the species encountered there were those that were not recorded in every previous years (Whooper swan, bean goose, great snipe), as well as the appearance of those that are registered on this site for the first time – Greylag goose (*Anser anser*), a species included in the Red Book of the Russian Federation and the Tomsk region, as well as Ferruginous duck (*Aythya nyroca*) which is also included in the Red Book of the Russian Federation.

However, it should be taken into account that not only the number of species encountered, but also their abundance is an important indicator for biodiversity and also for assessing the state of the resource of aquatic birds. Therefore, Table 2 compares quantitative indicators of individual species with similar records in 2000. From the comparison, it can be inferred that the numerical indicators have decreased in the last two decades for the vast majority of waterfowl species, including coots and reed warblers, plover, and grebes. At the same time, the number of species such as grey heron, Whooper swan, gadwall, northern shoveler, smew, goosander, corncrake and Heuglin's gull is increasing. It is relatively stable in great crested grebe (Fig. 18), mallard, common teal, common goldeneye, green sandpiper, wood sandpiper, common gull and little tern.

Table 2: Comparison of the spring bird population of the Kolarovo wetlands in 2000 and in 2021

№	Species	Average migration intensity, Individuals/hour		Average density, Individuals/km. sq.		Trend
		2000	2021	2000	2021	
1	Black-necked grebe <i>Podiceps nigricollis</i> (C. L. Brehm, 1831)	–	–	1.31	0.25	↓
2	Great crested grebe <i>Podiceps cristatus</i> (Linnaeus, 1758)	0.07	0.03	2.21	2.51	=
3	Eurasian bittern <i>Botaurus stellaris</i> (Linnaeus, 1758)	–	–	0.98	0.39	↓
4	Grey heron <i>Ardea cinerea</i> (Linnaeus, 1758)	0.02	0.07	0.18	9.32	↑
5	Black stork <i>Ciconia nigra</i> (Linnaeus, 1758)	–	–	–	0.04	?
6	Greylag goose <i>Anser anser</i> (Linnaeus, 1758)	–	0.11	–	–	?
7	Bean goose <i>Anser fabalis</i> (Latham, 1787)	–	0.01	–	–	?
8	Whooper swan <i>Cygnus cygnus</i> (Linnaeus, 1758)	–	0.48	0.15	0.04	↑
9	Mallard <i>Anas platyrhynchos</i> (Linnaeus, 1758)	0.96	0.73	6.99	9.99	=
10	Eurasian teal <i>Anas crecca</i> (Linnaeus, 1758)	0.79	0.25	12.83	15.70	=
11	Garganey	1.04	0.14	39.95	15.78	↓

	<i>Anas querquedula</i> (Linnaeus, 1758)					
12	Gadwall <i>Anas strepera</i> (Linnaeus, 1758)	0.04	0.09	0.14	4.24	↑
13	Eurasian wigeon <i>Anas penelope</i> (Linnaeus, 1758)	1.19	0.50	31.33	10.56	↓
14	Northern pintail <i>Anas acuta</i> (Linnaeus, 1758)	3.67	2.70	48.73	17.71	↓
15	Northern shoveler <i>Anas clypeata</i> (Linnaeus, 1758)	0.48	0.21	7.60	12.51	↑
16	Common pochard <i>Aythya ferina</i> (Linnaeus, 1758)	0.89	0.20	43.86	22.45	↓
17	Ferruginous duck <i>Aythya nyroca</i> (Güldenstädt, 1770)	–	–	–	0.07	?
18	Tufted duck <i>Aythya fuligula</i> (Linnaeus, 1758)	0.19	0.02	8.28	3.25	↓
19	Common goldeneye <i>Bucephala clangula</i> (Linnaeus, 1758)	0.64	0.42	2.40	6.01	=
20	Smew <i>Mergus albellus</i> (Linnaeus, 1758)	–	0.07	0.07	1.51	↑
21	Common merganser <i>Mergus merganser</i> (Linnaeus, 1758)	0.18	0.42	–	1.16	↑
22	Common crane <i>Grus grus</i> (Linnaeus, 1758)	–	0.05	–	0.07	?
23	Spotted crake <i>Porzana porzana</i> (Linnaeus, 1766)	–	–	0.35	0.18	↓
24	Corn crake <i>Crex crex</i> (Linnaeus, 1758)	–	–	–	0.08	?
25	Common moorhen <i>Gallinula chloropus</i> (Linnaeus, 1758)	–	–	0.61	0.11	↓

26	Eurasian coot <i>Fulica atra</i> (Linnaeus, 1758)	–	–	27.77	0.99	↓
27	Little ringed plover <i>Charadrius dubius</i> (Scopoli, 1786)	0.04	–	13.31	0.61	↓
28	Northern lapwing <i>Vanellus vanellus</i> (Linnaeus, 1758)	0.44	0.12	9.77	2.04	↓
29	Green sandpiper <i>Tringa ochropus</i> (Linnaeus, 1758)	0.08	0.07	0.75	1.84	=
30	Wood sandpiper <i>Tringa glareola</i> (Linnaeus, 1758)	0.12	0.05	0.50	7.24	=
31	Common greenshank <i>Tringa nebularia</i> (Gunnerus, 1767)	0.08	–	1.47	0.04	↓
32	Common redshank <i>Tringa totanus</i> (Linnaeus, 1758)	0.11	–	2.25	0.07	↓
33	Marsh sandpiper <i>Tringa stagnatilis</i> (Bechstein, 1803)	0.05	–	4.26	0.04	↓
34	Common sandpiper <i>Actitis hypoleucos</i> (Linnaeus, 1758)	0.05	0.01	13.54	6.67	↓
35	Terek sandpiper <i>Xenus cinereus</i> (Güldenstädt, 1775)	–	–	–	0.04	?
36	Ruff <i>Philomachus pugnax</i> (Linnaeus, 1758)	1.27	0.58	10.69	3.97	↓
37	Temminck's stint <i>Calidris temminckii</i> (Leisler, 1812)	0.51	–	0.32	0.18	↓
38	Jack snipe <i>Limnocryptes minimus</i> (Brünnich, 1764)	–	–	–	0.08	?
39	Common snipe <i>Gallinago gallinago</i> (Linnaeus, 1758)	0.02	–	0.93	0.62	↓
40	Great snipe <i>Gallinago media</i>	–	–	0.38	0.05	↓

	(Latham, 1787)					
41	Eurasian curlew <i>Numenius arquata</i> (Linnaeus, 1758)	0.01	0.02	0.22	0.05	↓
42	Black-tailed godwit <i>Limosa limosa</i> (Linnaeus, 1758)	–	0.01	0.11	0.04	↓
43	Little gull <i>Larus minutus</i> (Pallas, 1776)	0.03	–	0.39	0.11	↓
44	Black-headed gull <i>Larus ridibundus</i> (Linnaeus, 1766)	0.45	0.07	6.92	4.17	↓
45	European herring gull <i>Larus argentatus</i> (Pontoppidan, 1763)	–	0.02	–	3.54	↑
46	Common gull <i>Larus canus</i> (Linnaeus, 1758)	0.25	0.14	0.61	1.16	=
47	Black tern <i>Chlidonias niger</i> (Linnaeus, 1758)	0.14	–	41.18	0.24	↓
48	White-winged tern <i>Chlidonias leucopterus</i> (Temminck, 1815)	–	–	15.63	0.07	↓
49	Common tern <i>Sterna hirundo</i> (Linnaeus, 1758)	0.24	–	8.40	2.58	↓
50	Little tern <i>Sterna albifrons</i> (Pallas, 1764)	0.03	–	–	0.41	=
Notations: ↓ and ↑ - decrease and increase in abundance, = stable abundance, ? - requires clarification						



Figure 18: Great crested Grebe photographed by Soham Ray



Figure 19: Red necked phalarope photographed by Soham Ray

In addition to the aquatic birds mentioned above, about 75 more species - representatives of other ecological groups (meadow, forest, synanthropic, as well as semi-aquatic birds from other orders, for eg. Passeriformes and Coraciformes) were recorded at this site in different years. Of these, 70 were encountered this year in the summer-autumn period. All this indicates a fairly high diversity of birds and the high importance of Kolarovo wetlands as their habitat. Potentially, the list of bird species of this ecosystem may even reach or exceed 200 species, since, for eg. the 146 species mentioned above do not include any representative of the order of owls and a number of other orders, which are generally quite typical of the lower reaches of the Tom river and the vicinity of Tomsk, but were not registered directly on the territory of the studied area.

During the counting of the summer-autumn population of aquatic birds of this territory, only 16 species were registered. Among them are Red necked phalarope (Fig. 19) and Spotted Redshank – species that were not encountered in this spring. As noted above, the summer bird population has become significantly poorer in recent years compared to the data of previous years. This is confirmed by a sharp decrease in the number of recorded species by about two times compared to the end of the 20th century to the beginning of the 21st century, as well as their abundance (Table 3).

Table 3: Comparison of the summer-autumn bird population of the Kolarovo wetlands in 2000 and in 2021

№	Species	Average density, Individuals/km.sq.		Trend
		2000	2021	
1	Black-necked grebe <i>Podiceps nigricollis</i> (C. L. Brehm, 1831)	4.33	–	↓
2	Great crested grebe <i>Podiceps cristatus</i> (Linnaeus, 1758)	9.33	0.17	↓

3	Eurasian bittern <i>Botaurus stellaris</i> (Linnaeus, 1758)	0.45	0.17	↓
4	Grey heron <i>Ardea cinerea</i> (Linnaeus, 1758)	3.21	13.29	↑
5	Black stork <i>Ciconia nigra</i> (Linnaeus, 1758)	—	1.22	↑
6	Mallard <i>Anas platyrhynchos</i> (Linnaeus, 1758)	49.10	35.66	=
7	Eurasian teal <i>Anas crecca</i> (Linnaeus, 1758)	16.33	33.38	↑
8	Garganey <i>Anas querquedula</i> (Linnaeus, 1758)	3.28	8.22	=
9	Gadwall <i>Anas strepera</i> (Linnaeus, 1758)	—	0.52	↑
10	Eurasian wigeon <i>Anas penelope</i> (Linnaeus, 1758)	40.38	4.80	↓
11	Northern pintail <i>Anas acuta</i> (Linnaeus, 1758)	2.24	10.66	↑
12	Northern shoveler <i>Anas clypeata</i> (Linnaeus, 1758)	3.93	1.22	=
13	Common pochard <i>Aythya ferina</i> (Linnaeus, 1758)	3.05	—	↓
14	Tufted duck <i>Aythya fuligula</i> (Linnaeus, 1758)	2.88	—	↓
15	Smew <i>Mergus albellus</i> (Linnaeus, 1758)	1.83	—	↓
16	Baillon's crake <i>Porzana pusilla</i> (Pallas, 1776)	2.24	—	↓
17	Common moorhen <i>Gallinula chloropus</i>	0.15	0.17	?

	(Linnaeus, 1758)			
18	Eurasian coot <i>Fulica atra</i> (Linnaeus, 1758)	63.10	0.17	↓
19	Grey plover <i>Pluvialis squatarola</i> (Linnaeus, 1758)	0.06	—	?
20	Northern lapwing <i>Vanellus vanellus</i> (Linnaeus, 1758)	11.02	—	↓
21	Green sandpiper <i>Tringa ochropus</i> (Linnaeus, 1758)	4.08	—	↓
22	Wood sandpiper <i>Tringa glareola</i> (Linnaeus, 1758)	10.82	—	↓
23	Common greenshank <i>Tringa nebularia</i> (Gunnerus, 1767)	0.48	—	↓
24	Common redshank <i>Tringa totanus</i> (Linnaeus, 1758)	0.16	—	↓
25	Spotted redshank <i>Tringa erythropus</i> (Pallas, 1764)	—	1.40	?
26	Marsh sandpiper <i>Tringa stagnatilis</i> (Bechstein, 1803)	2.60	—	↓
27	Common sandpiper <i>Actitis hypoleucos</i> (Linnaeus, 1758)	2.41	—	?
28	Red-necked phalarope <i>Phalaropus lobatus</i> (Linnaeus, 1758)	0.80	0.17	?
29	Ruff <i>Philomachus pugnax</i> (Linnaeus, 1758)	2.32	—	↓
30	Snipes <i>Gallinago gallinago</i> (Linnaeus, 1758)	74.01	3.15	↓
31	Black-tailed godwit <i>Limosa limosa</i> (Linnaeus, 1758)	8.48	—	↓

32	Common gull <i>Larus canus</i> (Linnaeus, 1758)	1.36	—	↓
33	Black tern <i>Chlidonias niger</i> (Linnaeus, 1758)	31.46	—	↓
34	White-winged tern <i>Chlidonias leucopterus</i> (Temminck, 1815)	2.45	—	↓
35	Common tern <i>Sterna hirundo</i> (Linnaeus, 1758)	3.94	—	↓
Notations: ↓ and ↑ - decrease and increase in abundance, = stable abundance, ? - requires clarification				

A decrease in the abundance and diversity of bird species occurred in almost all taxonomic groups. This is especially noticeable in the sandpipers and gulls. The latter stopped nesting on these reservoirs, probably due to a decrease in the water level, which could lead to a decrease in the number of other groups of birds (grebes, ducks, Eurasian coot) that were protected by colonial birds. The decrease in water availability obviously affected the number of waders – if mudflats and flooded hummock with sedge vegetation were previously present, now most of these areas are covered with dense high-stemmed grass, not attracting in particular Snipe, which has turned from a mass into a rare species. Waterfowl also began to nest less – Common pochard and Tufted duck completely disappeared, the number of Common coot and Eurasian wigeon significantly decreased. The number of Common teals has noticeably increased, although perhaps due to non-local birds making post-nesting migrations. The number of Mallards looks relatively stable, probably the number of Pintail, Northern shoveler and Gadwall has increased. The Grey heron, which has a large colony formed on the island on the Tom River, has noticeably increased its number, and the Black stork has also become more common.

The reason for such a decrease in the diversity of birds can be illustrated by a snapshot of the summer water level of lakes (Fig. 20), which, due to the almost

continuous overgrowth of the aquatic vegetation, becomes unattractive for birds making post-nesting movements, and some of the local birds probably leave the territory earlier than before. Although it still plays an important role for waterfowl, but the abundance of birds is also lower.



Figure 20: Low summer water level of the Kolarovo wetlands (July, 2020)

On the contrary, in the spring after the snow melts, in almost any year the lakes are still quite full-flowing, which attracts many birds during the migration period who choose this territory for recreation and feeding (Fig. 21). Some species stay here for several days, because during the hunting period, due to the security regime, the territory acts as a kind of island of security, although there are cases of poaching here. Thus, the territory of the Kolarovo wetlands remains valuable for birds, especially during the spring flight, but has become less attractive in the summer-autumn period. For the vast majority of species of waterfowl and near-water birds, there is a decrease in abundance indicators, which is confirmed by the data of records for other territories.



Figure 21: High spring water level of Kolarovo wetlands (May, 2021)

CONCLUSION

1. Genetic study:

By phylogenetic analysis of mtDNA CR region of the three head samples of Bean Goose we have found two of them were related to tundra subspecies (*A.f. rossicus* and *A.f. serrirostris*) while the other was related to *A.f. middendorffii* or a close hybrid of the same. This further shows the presence of the rare subspecies of bean goose namely *A.f. middendorffii* in the tundra zone of West Siberia. Hence, this region should also be suggested to be included in the range of *A.f. middendorffii*.

2. Species study:

We have found *Riparia riparia* had 52.6% of nests compared to the *Riparia diluta* with 47.3% of nests which showed a clear differentiation in the height of choosing nest burrows with the higher nest holes in the colony occupied by the early arriving Pale Sand Martins. Average nest height comparison between the two species: $Z = -2.66$, $P = 0.07$. Though both the species have shown indicators of coexistence through cooperative mobbing and mixed colony nests but, the separation of nests by heights and lack of pair mixing also provide indicator of probable competition and further evolutionary differentiation into twin species.

3. Ecosystem study:

During observation of populations of birds on Kolarovo lakes we recorded 50 species in spring and 16 species in the summer of 2021 compared to 39 species in spring and 32 species in the summer of 2000. By comparative study from previous decade's records, a decrease in the abundance and diversity of bird species were seen in almost all taxonomic groups. This decrease in the summer population of birds was mainly due to the overgrowth of the aquatic vegetation making the wetlands unsuitable for aquatic birds. Thus, focus is needed on biological conservation and wetland management efforts.

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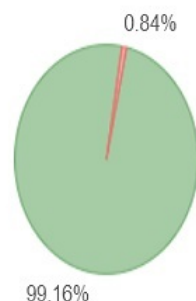
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