Influence of Changes in Agricultural Landscapes on the Distribution and Number of the Demoiselle Crane (*Anthropoides virgo* Linnaeus, 1758) (Gruidae, AVES) in its Breeding Range Since the Middle of the XX Century

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Abstract—The status of populations of the Demoiselle Crane *Anthropoides virgo* (Linnaeus, 1758), more than other crane species, depends on changes in agricultural landscapes as economic development affected almost the entire species breeding range in the steppes and semi-deserts of Eurasia. Large-scale and intensive expansion of agricultural landscapes in the USSR in the 1950s—1960s, accompanied by a complex of limiting factors, caused a sharp decline in Demoiselle Crane numbers and redistribution within the breeding range. In the 1970s—1980s this species, thanks to its high ecological and ethological flexibility, took advantage of the agricultural landscapes increase due to the mass transition to breeding on cultivated fields. After the USSR collapse in 1991, the Demoiselle Crane reaction to the withdrawal of a huge area of fields and pastures from economic use in different parts of the species distribution proved to be ambiguous. The decrease in numbers in the south, the west, and the east of the distribution was compensated by its increase or a stable status in the central and northern parts of the breeding range. As a result, the world population as a whole changed insignificantly from 200000–240000 to 170000–220000 individuals.

Keywords: Demoiselle Crane, distribution, number, agriculture

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INTRODUCTION

The fastest and most intensive changes in agriculture around the world began in the XX century, after the Second World War, under the influence of socioeconomic and political factors and scientific and technological progress. The rapid and widespread transformation of natural habitats has led to a reduction in the number of most crane species as well as the disappearance of some populations.

The specialized species were most affected because they had not enough time to adapt to changes in natural landscapes. At the same time, some more flexible species or populations have benefited from the development of agricultural activities. The former one is the Demoiselle Crane (*Anthropoides virgo* Linnaeus, 1758). This species is the original inhabitant of the dry steppes and semi-deserts of Eurasia, which historically more than any other geographical areas have undergone agricultural development. Over the centuries, the Demoiselle Crane gradually adapted to live in agricultural landscapes. The moderate plowing of the steppes itself over an historically long time did not have a strong negative effect on its number and distribution. In old-developed areas in the western European part of the range the Demoiselle Crane switched to breeding on agricultural fields in the IXX century (Andryushchenko, 1997). However, the rapid spasmodic conversion of virgin lands into cultivated fields, the massive use of pesticides, intensive cattle grazing, the use of agricultural machinery, poaching and increasing disturbance, combined with abiotic (climatic, hydrological and soil changes) and biotic (shepherd dog predation) factors led to the disappearance or degradation of some populations for even such a flexible species in different periods of time.

These changes, which became intensive in the XIX century in Western Europe, quickly spread to the east in XX and XXI centuries. In the first half of the XX century, breeding populations disappeared in the old-developed densely human populated agricultural regions of Western Europe (Andryushchenko, 1997; Nankinov, 2009), as well in Tajikistan (Ivanov, 1969) and Armenia (Lyaister and Sosnin, 1942). In the late XX century, due to intensive economic development, two isolated populations in North Africa and Turkey (Ilyashenko, E.I. and Ilyashenko, V.Y., 2011; Akarsu et al., 2013) as well as breeding populations in the provinces of Gilin and Heilunjiang in China (Su Liying,
The article considers how various factors accompanied these macroeconomic events: 1) irrigation and development of virgin and fallow lands 2) the economic crisis and the reorganization of the agricultural system since the late 1990s after the collapse of the USSR. The article considers how various factors accompanying these macroeconomic events influenced the distribution and numbers of the Demoiselle Crane since the mid-XX century.

MATERIALS AND METHODS

The analysis of the Demoiselle Crane reaction to changes in agricultural landscapes was implemented based on our own observations and an extensive review of the literature. Fieldwork conducted from 1987 to 2017 in different Demoiselle Crane habitats (Republics of Kalmykia and Dagestan, Volgograd Region, Stavropol and Trans-Baikal Territories, North Africa and Turkey) made it possible to adequately evaluate the published data and identify the main factors affecting the distribution and numbers of the species since the middle of the XX century.

RESULTS AND DISCUSSIONS

Since the middle of the XX century, macroeconomic processes in the former USSR countries identified three temporal periods in changes in numbers and the breeding area structure of the Demoiselle Crane. The first, from the 1950s to the 1970s, was a period of species depression with a sharp decrease in numbers due to large-scale changes in agricultural landscapes. The second, from the 1970s to 1980s, is characterized by the number of recovering and habitat expansion, due to the massive transition of the species to breeding in the transformed landscape. The third, the early 1990s showed the controversial reaction of the Demoiselle Crane to changes in agricultural landscapes in different parts of the breeding range, depending on the level of economic development in habitat areas and climate change.

Irrigation and development of virgin and fallow lands in the USSR in the 1950s—1960s was the grandiose socio-economic project of the XX century which had no analogues in world history. In the early 1950s, war-weakened agriculture and, in particular, the bad situation with bread supply in the country, began to cause serious concern and measures had to be taken to meet the nutritional needs of people, and agricultural raw materials for industry. Of the two ways, one was intensive development in the already developed agrarian regions and the second was extensive development of new lands in the steppe zone. The country’s leadership chose the latter, since efforts to intensify agriculture required long-term efforts and large funds, while the extensive development way could give quick results. In a short period (from 1954 to 1960) 41.8 million hectares of virgin and fallow lands were plowed, including 16.3 million hectares in the Russian Federation (1.7 million hectares in Volga Region, 4.2 million hectares Ural Region; 6.2 million hectares in Western Siberia, and 4.2 million hectares in Eastern Siberia and the Russia Far East) (Nefedova, 2014); 25.5 million hectares in Kazakhstan, mainly in the north (Kustanai, Northern Kazakhstan, Akmola and Pavlodar Regions) (Kamp et al., 2011). Large-scale development of virgin lands covered vast territories in the steppe zone of Ukraine, southern Russia and northern Kazakhstan and led to the rapid disappearance of the natural or pasture biotopes of the Demoiselle Crane and the development of arable areas there instead (Neufeldt and Kovshar, 1991; Krivitsky, 1999).

Plowing of vast virgin lands gave the first positive results already in 1956: a record crop of 125 million tons of grain was collected, of which 50% was obtained on virgin lands. However, the organization of this massive campaign did not take into account the difficult climatic conditions (harsh winters and dry summers) and the soil quality of the developed steppe regions. The ecological balance was disturbed; and wind erosion, especially in the vast areas of Kazakhstan, began to turn into a serious problem already in the late 1950s.

To combat dust storms, mass forest planting was undertaken. This has become a factor in limiting the Demoiselle Crane transition to breed on cultivated fields, because forest belts, especially planted in relatively small fields in the western part of the breeding range, limit visibility, reduce safety, and block access to water bodies (Winter, 1991; Taranenko, 1991).

The plowing of the vast areas of virgin lands led to a sharp reduction in hay and pasture lands and led to the beginning of a long-time crisis in livestock husbandry, especially in Ukraine and Russia. In 1955, a Decree of the Central Committee of the Communist Party of the Soviet Union (CPSU) obligated state farms to raise livestock. This caused pasture degradation due to overgrazing on the remaining virgin lands, as well as an increase in crane disturbance and the...
death of clutches and chicks during livestock grazing due to the predation of shepherd dogs (Kovshar and Berezovikov, 1990; Neufeldt and Kovshar, 1991).

The development of new arable lands and livestock husbandry was accompanied by large-scale irrigation. Irrigated agriculture, especially in the western areas of the range, has reduced the area of suitable Demoiselle Crane habitats. The construction of dams, the summer discharge of water caused flooding of crane nests near water bodies and had an extremely negative affect on the species (Krivitsky, 1999).

In the 1960s, the most severe threat became the large-scale use of pesticides, including DDT, for intensification of pest control in agriculture. This turned out to be a significant limiting factor causing the Demoiselle Crane numbers to decline (Winter, 1991). In the 1970s, DDT was prohibited. However, other pesticides, mainly against locusts, are still used. The death of adult birds from poisoning as a result of spraying chemicals over fields during the species incubation period has been repeatedly noted (Taranenko, 1991).

Along with such a sharp deterioration in the Demoiselle Crane breeding conditions, disturbance has increased by a considerable amount. A mass inflow of human labor (for example, in 1954–1956, about 50 thousand people arrived in Kazakhstan to develop virgin lands), the appearance in the formerly almost uninhabited steppe of machinery, various construction, canals, artificially planted forest belts, electric power lines, roads and railways caused low breeding success and the death of clutches and chicks of Demoiselle Cranes (Taranenko, 1991; Andryushchenko, 1997; Krivitsky, 1999). Direct prosecution played a major negative role: illegal hunting for Demoiselle Cranes, Bustards and other birds from vehicles was very widespread in the 1950s (Krivitsky, 1999; Belik, 2015).

Thus, the rapid and large-scale development of virgin and fallow lands, accompanied by livestock overgrazing on the remaining pastures, irrigation, poaching, increased disturbance and pesticide use, had a powerful negative impact on the species. A sharp decrease in the number and redistribution within the range occurred. In the western part of the distribution, the Demoiselle Crane has survived in small areas with the least economic load (rocky or clay natural biotopes, protected areas) used as refuges. In Kazakhstan the species has moved to the semi-desert and desert zones (Kovshar, 1982), where it was able to survive a powerful anthropogenic press. Breeding on new arable lands in the 1970s has not yet been noted (Golovanova, 1982).

After the mass campaign of the 1970s—1980s, due to the regulation of hunting and the prohibition of strong pesticide use, as well as due to ecological flexibility, there was a mass transition of the Demoiselle Crane to breeding on cultivated fields (Neufeldt and Kovshar, 1991; Kovshar, 1993). Initially, they returned to farmland in the old developed areas of the European part of the range where virgin lands were limited. Then, by the late 1980s, breeding on agricultural fields became a common occurrence from the Black Sea Region to Altai steppes (Neufeldt and Kovshar, 1991). Ethological flexibility of this species (getting used to people and livestock in the absence of direct pursuit) made it possible for it to use pastures for breeding in the immediate vicinity of villages and livestock farms. Moreover, the plowing of virgin lands and the development of livestock husbandry contributed to the expansion of the southern and northern borders of its breeding range. Through cultivation, open agricultural landscapes appeared in the north of the range; and livestock grazing led to the degradation of high grass steppes, on which, due to overgrazing, areas similar to dry steppe suitable for Demoiselle Crane breeding appeared (Kovshar, 1993). In the southern arid habitats, with the development of livestock husbandry and arable farming, a network of irrigation canals has grown as well as artificial reservoirs have been created for the watering of domestic animals. This facilitated an increase in the Demoiselle Crane numbers and the development of its new breeding habitats in the semi-desert and desert zones (Kovshar, 1982; Kovshar and Berezovikov, 1990; Neufeldt and Kovshar, 1991; Bukreeva, 2003; Berezovikov and Kovshar, 2006).

Thus, by the late 1980s, due to ecological adaptation to changing conditions and partial synanthropization, the Demoiselle Crane returned to breeding in areas where it had practically disappeared in the 1960s—1970s. Its numbers have recovered, and have grown in some of the most favorable habitats. There was an expansion of the breeding range to the north and south, as well as an increase in the number of suitable breeding habitats within the range.

The second large-scale macroeconomic change having a strong impact on the Demoiselle Crane was the economic crisis and the reorganization of agricultural system after the collapse of the Soviet Union in 1991. This caused a new period of destabilization for the species, its redistribution within the breeding range and decline in numbers in some areas (Berezovikov, 2002; Berezovikov and Kovshar, 2006; Belik et al., 2011, 2011; Chernobay, 2011; Goroshko, 2012). In the 1990s, the economic crisis led to a significant decrease in the volume and intensity of agricultural production in Ukraine, Russia, and Kazakhstan, which led to the withdrawal of vast arable lands from agricultural use in the steppe zone and a strong reduction in livestock numbers (Nefedova, 2014). For the Demoiselle Crane that switched to breeding on cultivated lands by the late 1980s in the most parts of its range, the curtailment of arable farming led to a significant change in breeding conditions (Berezovikov and Kovshar, 2006). A deep crisis in livestock farming has also led to the degradation of Demoiselle Crane habitats. In Russia alone, the number of cattle decreased from 57 to 20.1 million in 2011, and the share of livestock in gross
agricultural production—from 63% in 1990 to 44% in 2000 (Nefedova, 2014).

In the first crisis years, a decrease in disturbance due to the cessation of economic activity in arable lands and a reduction in livestock numbers had a positive effect on the Demoiselle Crane. In some areas, its numbers even increased (Gubin, 2002; Bukreeva, 2003; Bukreev and Dzhamirzoev, 2006). The absence of disturbance or its low level was one of the main factors that attracted the Demoiselle Crane to breed on the fallow lands, which were formed because of the withdrawal of a significant part of arable lands and characterized by low economic activity there (Korovin, 2009; Bragin, 2011). In addition, in fallow lands the death of clutches in the process of mechanized tillage is excluded, while it is the main factor of mortality during breeding on cultivated fields.

However, in 2–3 years after the land withdrawal, the fallow lands were overgrown with high weed vegetation, and became unsuitable for Demoiselle Crane breeding (Andryushchenko, 2015). In the mid or late 1990s, the withdrawal of significant parts of arable lands and climate humidization, especially in the European part of the Demoiselle Crane range, caused rapid vegetation restoration on fallow lands (Oparin et al., 2002; Belik, 2015). Besides, an approximately tenfold reduction in livestock grazing load in pastures also led to overgrowth. As a result, in some areas where the species number had initially increased, in subsequent years it declined again due to the reduction in suitable breeding habitats. However, in some agricultural areas in the north of the breeding range, where grain production was continued, albeit on a smaller scale, or where limited economic activity was carried out on fallow lands (cattle herding, hayfields), or because of the arid climate, the Demoiselle Crane kept its positions (Bereozovik and Kovalenko, 2001; Korovin, 2009; Bragin, 2011).

Macroeconomic changes in the 1990s were accompanied by climate change. A reduction of climate continentality (humidification in summer and warming in winter) and climate warming have led to a decrease in the steppe waterering (Belik, 2015). While in the 1960s–1980s, drying of natural waterbodies was partially compensated by construction of irrigation canal systems and water storage ponds, then by the late 1990s irrigated agriculture and livestock husbandry fell into disrepair, water supply stopped, most canals and ponds dried up, and many artesian wells disappeared.

Due to the reduction of water resources, government agencies took measures to save water. In some areas, a fee was introduced for canals and artesian wells use which led to their abandonment due to the insolvency of the rural population. All this significantly reduced suitable crane habitats; and long-term drought since the mid-2000s in the Eurasian steppes and especially the abnormal heat in 2010, further aggravated the negative status of the species (Goroshko, 2011; Malovichko, 2011).

The decline in agriculture, accompanied with drought, has led to increased fires since the late 1990s causing significant damage to the steppe biodiversity. Due to overgrowing of fields and pastures with thick grass, large summer fires have spread over vast areas of dry steppes and semi-deserts (Bragin, 2006; Badmaev, 2006; Chernobay, 2011; Goroshko, 2012; Belik, 2015). For example, in Kalmykia, on core breeding habitats in the European part of the Demoiselle Crane range, the total burned area amounted to about 600 thousand hectares in 2000–2002 (Bukreeva, 2003). In the first years after fires, Demoiselle Cranes use open burned areas, but often in subsequent years, the composition of grass changes in such places, and they become unsuitable for breeding (Belik et al., 2011).

Thus, in the 1990s—early 2000s, the crisis in agriculture, coupled with long-term drought, led to a significant change in the biotopic confinement of the Demoiselle Crane. There was a further shift of the northern range border to the north to the forest-steppe zone; the species number in arable land areas remained stable or increased slightly due to breeding in the cultivated and fallow lands. In Southern Kazakhstan and in some livestock husbandry regions in Northwestern Caspian Region and Trans-Baikal Territory, the disappearance or decrease in accessibility of most water bodies due to long-term drought and destruction of irrigation systems led to a significant decline in Demoiselle Crane numbers, fragmentation or disappearance of its habitats and a shift of the southern range border to the north (Kovshar, 2010; Goroshko, 2012; Belik, 2015). The numbers in East Kazakhstan and the Volgograd Trans-Volga region also decreased significantly.

Since about the mid-2000s, many post-Soviet trends in agriculture have changed towards the expansion and intensification of arable farming in the steppe zone of Kazakhstan and in the south of Russia (Nefedova, 2014), which led to further changes in Demoiselle Crane habitats. In agricultural areas, the species began to return to the newly cultivated fields (Fedosov and Malovichko, 2008; Korovin, 2009; Andryushchenko, 2011; Bragin, 2011). In fields that remained withdrawn from their economic use, the natural steppe vegetation has recovered due to succession processes. Such restored plots, especially if they were used for moderate grazing, the Demoiselle Crane populated again (Andryushchenko, 2011). The ongoing drought contributed to a further shift of the northern range border to the forest-steppe zone, where in some areas it reached 52°–56° N (Fefelov, 2008, 2015; Pavlov et al., 2009; Savchenko and Emelyanov, 2012).

However, in arid regions, the status of Demoiselle Crane habitats has not improved much due to the ongoing drought and reorganization of livestock farming associated with a change in land ownership. In
Since the middle of the XX century, in the biggest part of the breeding range the Demoiselle Crane experienced a sharp decline in numbers due to large-scale and intensive changes in agricultural landscapes in the 1950s–1960s; and then the number restoration and expansion of the breeding range to the north and south due to adaptation to breeding in transformed landscapes in the 1970s–1980s. An increase in the number and area of breeding habitats during this period allowed it to survive the next large-scale macroeconomic change in agricultural landscapes in the 1990s–2000s that occurred as a result of the economic crisis and the reorganization of agricultural system after the USSR collapse. In general, the 1950s–1960s and 1990s–2000s are considered as periods of a depressed state for the species (Kovshar, 2010).

Further intensification of agriculture, the ongoing crisis in livestock husbandry and climatic changes, acting synergistically, led to an ambiguous reaction of different Demoiselle Crane populations and had both positive and negative effects on their status. Currently, the breeding range has been shifted to the north due to the species moving into the forest-steppe zone and fragmentation and disappearance of its habitats in the south. The decrease in numbers in the south, west, and east of the breeding range partially compensated for its increase or stable state in the central and northern regions of the breeding range. Therefore, in general, the world population has changed slightly – from 200–240 thousand (Meine and Archibald, 1996) to 170–220 thousand individuals (Ilyashenko, 2016).

CONCLUSION

Since the middle of the XX century, in the biggest part of the breeding range the Demoiselle Crane experienced a sharp decline in numbers due to large-scale and intensive changes in agricultural landscapes in the 1950s–1960s; and then the number restoration and expansion of the breeding range to the north and south due to adaptation to breeding in transformed landscapes in the 1970s–1980s. An increase in the number and area of breeding habitats during this period allowed it to survive the next large-scale macroeconomic change in agricultural landscapes in the 1990s–2000s that occurred as a result of the economic crisis and the reorganization of agricultural system after the USSR collapse. In general, the 1950s–1960s and 1990s–2000s are considered as periods of a depressed state for the species (Kovshar, 2010).

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest. The author declares that she has no conflict of interest.

Statement on the welfare of animals. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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