Numbers, reproductive success and genetic structure of Lapwings *Vanellus vanellus* in areas of varying pastoral regimes

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Research was conducted in 1980-1989 on constant survey squares in the green belt of Lipetsk (the Central Chernozyom Region). One hundred and fifty-four nests were observed regularly until hatching. The number of Lapwings *Vanellus vanellus* breeding in the study area decreased markedly, from 90-100 pairs to 10-15 pairs. The causes of the decline are intensive cattle grazing, predation of clutches by Hooded Crows *Corvus corone cornix*, Magpies *Pica pica* and Rooks *Corvus frugilegus*, and recreational pressure. When moderate grazing by 100-150 head of cattle occured on a 400 ha area, 50-60 pairs of Lapwings nested each year, but after the cattle herd increased to 1,000 head, the number of breeding Lapwings decreased to 10-15 pairs. Average clutch size in 1980-1983 was 3.9±0.1, and the reproductive success was 46.1%. Over the next 12 years (1984-1996) the clutch size decreased to 3.3±0.3 and the reproductive success also decreased to 38.2%. In 1987-1989, clutch size (3.2±0.3) and reproductive success (28.2%) was further reduced. We consider non-metrical characteristics of eggs (colour and shell pattern) to be a reliable genetic marker for different bird groups. For Lapwing, there is a dependence between the scale of intra-population variety (M) and the number of breeding pairs. Hence in 1982, when the number of breeding birds was at its highest (100 pairs), M = 2.4±0.1. In more recent years, M has not exceeded 2.26.

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Исследования проводились в 1980-1989 гг. на квадратах постоянных исследований в зеленом поясе г. Липетск (Черноземный центр). Под регулярным наблюдением до вылупления были 154 гнезда. Численность гнездящихся в районе изучений чибисов *Vanellus vanellus* заметно снизилась, от 90-100 пар до 10-15 пар. Причины сокращения численности - интенцивный выпас скота, разорение кладок серыми воронами *Corvus corone cornix*, сороками *Pica pica* и грачами *Corvus frugilegus*, и рекреационная нагрузка. При умеренном выпасе от 100 до 150 голов скота на площади 400 га гнездились каждый год от 50 до 60 пар чибисов, а при увеличении стада скота до 1,000 голов количество гнездящихся чибисов снизилось на всего 10-15 пар. Среднее количество яиц в кладке в 1980-1983 гг. было 3,9±0,1 и успех размножения был 46,1%. В течение следующих 12 лет (1984-1996) размер кладки уменьшился на 3,3±0,3, снизился и успех размножения на 38,2%. В период с 1987 по 1989 г. как размер кладки (3,2±0,3), так и успех размножения (28,2%) были еще ниже. Мы считаем неметрические характеристики яиц (окраска и рисунок скорлупы) надежным генетическим индикатором для различных групп птиц. Для чибиса есть зависимость между степенью внутрипопуляционного разнообразия (M) и количеством гнездящихся пар. Таким образом, в 1982 г., когда число гнездящихся птиц достигло пика (100 пар), M= 2,4±0,1. В последние же годы величина M не превышала 2,26.

Introduction

More than 60% of the total human population on the earth now lives in large cities and towns, making the impact of humans one of the most important current environmental issues. An improvement in the relationship between man and nature is now extremely urgent. Scientific knowledge of the reactions of natural communities to different kinds of anthropogenic influence will help achieve this end. Long-term studies enable a better understanding of both the positive and negative sides of the process of human modification of natural landscapes such as occurs on farmland.

Birds, being one of the most noticeable and well-studied vertebrate groups, can serve as good models for such studies. In many parts of European Russia the impoverishment of bird populations as a result of human influence has been slowed during the last two decades. Indeed, for several species, including Lapwing *Vanellus vanellus*, an increase in numbers has been recorded. The biology and ecology of this species have been rather well studied, although there are generally few breeding data from within urban landscapes.

Study Area and Methods

Our studies were conducted from 1973-1990 in the town of Lipetsk, situated in the central part of European Russia, and in the surrounding area, a total area of 400 ha (Figure 1). Between 1980 and 1989, studies were carried out on four sample plots each of 5 ha, of varying levels of anthropogenic influence. All the plots were located on moist flood-plain meadows with pools, ox-bow lakes, swamps and shrub-thickets along the Voronezh and the Matyra rivers. All the meadows were used for pasture (mainly by cows) and hay making; on plots 2 and 3, moderate pasturing occurred, while plots 1 and 4 suffered intense grazing. Plot 4 was within an area of active recreation and thus hay making only took place locally.

Dates of arrival and the beginning of nest-construction, egg-laying and hatching were recorded annually for all wader species. Every nest was marked with a metallic stick and its location mapped. Each nest was examined regularly, from six to ten times during the nesting period. Periodic standard wader counts and searches for nests were also carried out.

At the same time as this work was taking place, similar studies were carried out on a fifth sample plot 40 km from Lipetsk, which was characterised by only slight agricultural influence (sporadic pasturing and annual hay making from the second half of June onwards).

Egg success was estimated as the proportion of hatched chicks from the total number of eggs in nests being studied.

As well as these traditional field methods, a new one was used: the phenetic approach, based on the analysis of the colour of the egg-shell (Klimov *et al.* 1989, 1990). As has been shown by Myand (1988), by our studies (Klimov 1987, 1990, 1991; Klimov & Ovchinnikova 1988, 1992; Klimov *et al.* 1990, 1992a, 1992b, 1992c; Ovchinnikova & Klimov 1987), and by Vengerov (1989, 1990, 1991, 1992), eggs are convenient objects for the analysis of morphological variation in bird populations.
The colour of a Lapwing egg-shell is due to two components - diffusely spread pigment, called the background colour, and various lines, spots etc., called the tracery. Lapwing egg-shell colour is

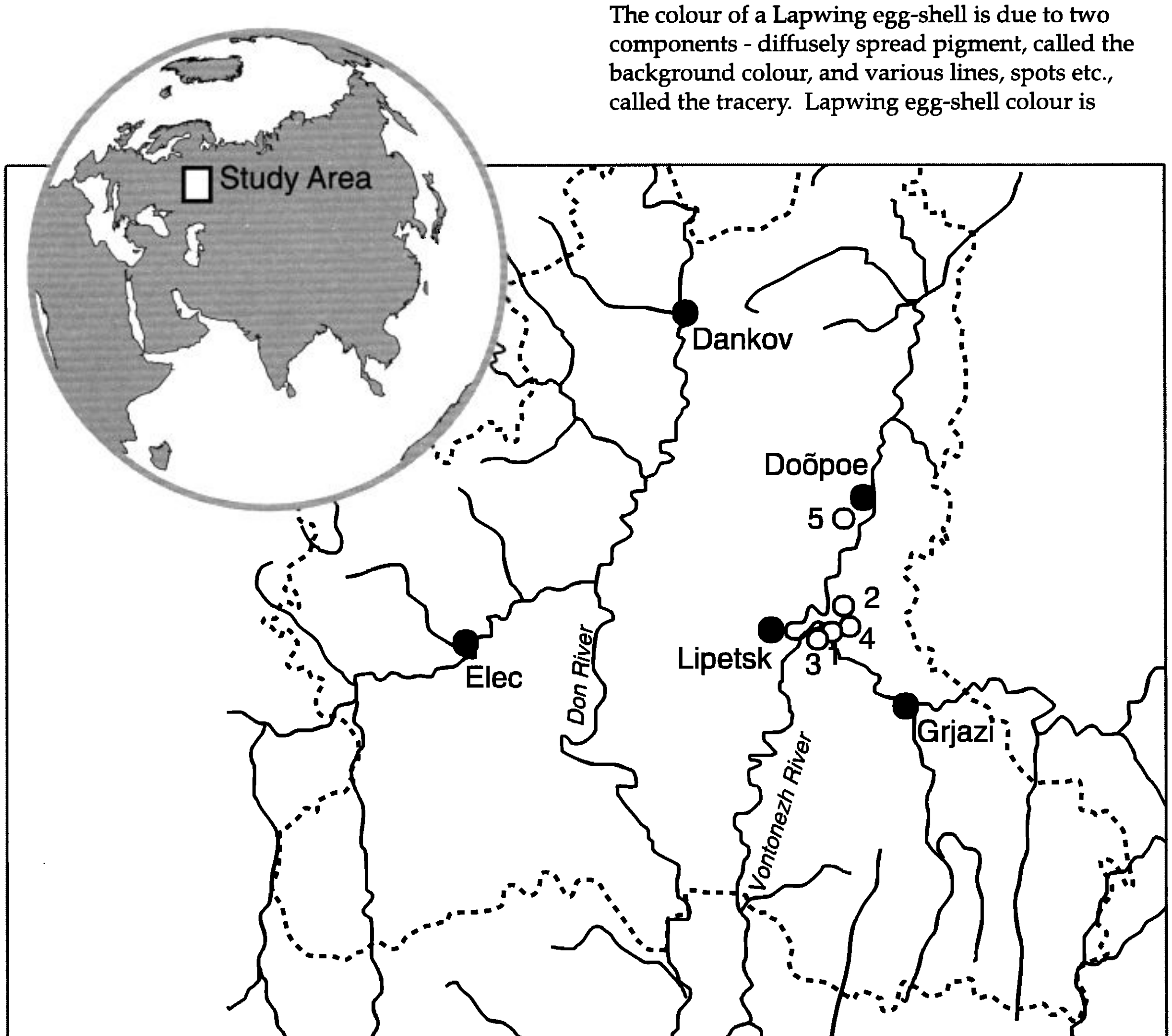

Figure 1. Study area and location of control plots. 1 - study area; 2 - control plots with numbers; 3 - administrative boundary of Lipetsk region.

therefore very complicated, as in the majority of open-nesting birds. Variations in background colour can be separated into three groups: sandy (varying from grey to olive tints, including those with light-blue background colour), green-brown (background colour from green to tobacco-brown) and intermediate sandy-green-brown. The tracery can also vary, depending on the form and combination of the elements, and their distribution and density over the egg-shell. The following tracery patterns can be distinguished:

1. *Form and combination of tracery elements*

Although these elements differ in shape and size, they can be included into one of two geometric groups: spots or lines. According to their combination on the egg-shell, four types of tracery were distinguished:

1.1. Spotty tracery - only the spots are present;
1.2. Spotty-linear - both lines and spots are present, although spots prevail;
1.3. Linear-spotty - both lines and spots are present, linear tracery prevails; or
1.4. Linear - only lines are present.

2. *Distribution of tracery elements over the whole egg-shell*

In general, the tracery elements are circularly concentrated at the obtuse end of the eggs, rarely at the acute one, and still more rarely at both of them. In addition, the tracery elements can be concentrated around the equatorial part of the egg, or spread diffusely over the whole egg. Thus, five types of distribution of tracery elements are recognised.

3. *Density of tracery*

Three types of tracery according to its density on the egg-shell were distinguished:

3.1. Scarce - less than 30% of the egg-shell covered with tracery elements;
3.2. Dense - tracery occupies 30% to 70% of the egg-shell; or
3.3. Solid - more than 70% of the egg-shell is covered with tracery.

For the quantitative estimation of this character under laboratory conditions, we used a polyethylene strip 10 x 10 mm in size with a 1 mm grid. The density of tracery elements was calculated according to the scheme described for two parts of the egg: close to the obtuse and to the acute ends. In the field, these estimations were made visually without the grid, as any under-estimation was not large and at the same time much more material could be collected.

Statistical analysis was carried out according to Zhivotovsky (1982). Using the three egg characteristics described, an average index of within-population colour diversity was calculated. Using this index, one can describe the differences between local populations and any relationships with differing levels of human influence.

Results and Discussion

Regular observations were made on 228 Lapwing nests, the majority of which were observed until hatching. During the studies, the breeding population of Lapwing within the study area declined from 90-100 pairs in the early 1980s, to 10-15 pairs in the late 1980s (Table 1). This was caused mainly by intensive grazing, destruction of nests by corvids (Hooded Crow *Corvus corone cornix*, Magpie *Pica pica*, Rook *C. frugilegus*), and recreational pressure. When moderate grazing of 100-150 head of cattle occured on a 400 ha area, 50 to 60 Lapwing pairs bred annually; when the herd increased to 700-1,000 head of cattle, numbers of breeding Lapwing declined to 10-15 pairs (Table 1). At the same time, changes in the distribution of Lapwing colonies and in the behaviour of birds were recorded. At the beginning of the study about 95% of Lapwing colonies were situated on flooded meadows, while the rest of the birds nested on bogs and hillocky marshes. In the later years of the study Lapwings settled mostly on the floating mats of bogs and, more rarely, on hillocky marshes, in groups of three to five pairs. This situation was observed at all the plots within the areas of farmland except plot 3, from which Lapwings disappeared in 1984 after it became overgrown with scrub.

We believe that the decline in egg success was due to the activities of avian predators, whose numbers in the study area are rather high: 15 pairs of Hooded Crows, 70 pairs of Magpies, and seven pairs of Marsh Harrier *Circus aeruginosus* (Klimov & Aleksandrov 1990). Low average clutch size, recorded in the last four years (Table 1) was explained by the increase in the number of replacement clutches, which were usually smaller.

On the areas with moderate grazing, Lapwings often formed mixed breeding colonies with other bird species, where the birds defended their nests more successfully against corvids and Marsh Harriers. The different defence strategies of the different species in mixed colonies probably increases the general resistance of such colonies to predation pressure (Aleksandrov 1985, 1986). The formation of mixed colonies within farmland can be considered to be one of the adaptations of birds to the presence of humans (Klimov 1988). At the same time, if the pressure of human activities, particularly agricultural ones, is even more intense, this kind of adaptation is not effective. The increased size of the cow herd in our study led to the trampling of places which were suitable for breeding, to the destruction and separation of mixed colonies into very small and mostly monospecific ones, and finally, to the decline in breeding success of Lapwing (Table 1) as well as other breeding bird species.

Studies of Lapwing ecology in plot 5 with slight agricultural influence revealed stable breeding numbers and a larger clutch size (mean = 3.8+0.2 SE for five years) in comparison with more intensively

Table 1. Numbers, clutch size, breeding success and genetic structure of Lapwing population in the pastoral areas (plots 1-4) of Lipetsk.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Size of cow-herd on the 400 ha area	100-150	100-150	100-150	100-150	200-500	200-500	200-500	700-1000	700-1000	700-1000
Number of nests studied	14	22	28	38	10	10	8	9	7	7
Estimated number of Lapwing nests on 400 ha	40-50	40-50	90-100	70-80	50-60	40-50	20-25	20-25	10-15	10-15
Clutch size m ± SE	3.81±0.2	3.9±0.1	3.9±0.1	3.9±01	3.2±0.3	3.7±0.2	3.1±0.3	3.2±0.3	3.3±0.3	3.1±0.3
Coefficient of variation for the clutch size (%)	15.3	7.5	10.7	9.8	28.7	18.2	32.7	25.9	23.0	28.6
Egg success (%)	42.7	46.5	51.0	44.4	38.7	39.6	36.2	30.5	28.3	25.8
Index of intra-population diversity ± SE	2.00.2	2.10.2	2.40.1	2.30.0	2.20.2	-	-	2.00.2	-	-

Table 2. Numbers, clutch size, breeding success and fenetic structure of Lapwing populations in areas surrounding Lipetsk town and subject to only slight agricultural management.

	1983	1984	1985	1986	1987
Size of cow-herd on the 400 ha area	150-200	150-200	150-200	250-400	250-400
Number of nests studied	18	10	12	11	15
Estimated number of Lapwing nests on 400 ha	60-70	40-50	50-60	40-50	50-60
Clutch size ±SE	3.9±0.1	3.8±0.2	3.9±0.2	3.8±0.2	3.9±0.2
Coefficient of variation in clutch size (%)	12.3	16.3	15.2	16.1	14.3
Egg success (%)	50.5	46.2	48.6	43.5	48.8
Index of intra-population diversity (m) ± SE	2.30.2	2.20.2	2.20.1	2.20.1	2.30.2

managed areas (mean=3.6±0.2 SE for ten years); chronological variation of clutch size and phenetic diversity of egg-shell colour in Lapwings from plot 5 were not large (Table 2). Changes in plot 5 similar to those in the more intensively managed area were also observed during the last years of the study. Due to an increase in cattle-grazing, Lapwings started to breed on the floating parts of bogs and total numbers declined.

Lapwings breeding in agriculturally modified areas start nesting 7-10 days earlier than birds in areas with little human influence (Table 3). In addition, the breeding season in agricultural areas is longer due to high rates of nest-failures and clutch replacement.

It is clear that Lapwings which breed in agriculturally modified areas differ greatly in a number of ecological characteristics from those which breed in less modified habitats: dates of particular stages of reproduction, length of breeding period, clutch size, variation of phenetic parameters, egg-success *etc.* Birds may be reasonably successful in those areas managed by men when the human influence on them remains moderate.

Table 3. The earliest dates of arrival and start of egg-laying in Lapwings breeding in the farmland areas compared with the slightly transformed habitats.

Year	Farmland areas Arrival date	 Laying date	Slightly transformed areas Arrival date	 Laying date
1980	2 April	19 April	no data	no data
1981	25 March	10 April	no data	no data
1982	31 March	17 April	1 April	24 April
1983	23 March	15 April	25 March	23 April
1984	24 March	10 April	24 March	20 April
1985	28 March	15 April	no data	22 April
1986	27 March	15 April	26 March	23 April
1987	31 March	18 April	31 March	26 April
1988	29 March	17 April	30 March	25 April
1989	30 March	17 April	1 April	26 April

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