POLSKA AKADEMIA NAUK
INSTYTUT ZOOLOGII

ACTA ORNITHOLOGICA

Tom XVII Warszawa, 30 IX 1980 Nr 16

Maciej GROMADZKI

Reproduction of the starling *Sturnus vulgaris* in Żuławy Wiślane, North Poland

GROMADZKI, M. 1979. Reproduction of the starling *Sturnus vulgaris* in Żuławy Wiślane, North Poland. Acta orn. 17:195-226.

The degree to which nest boxes were utilized by starlings depended on the way they were put up and the period over which a given colony had existed. Females in their second summer and older ones took part in breeding; the percentage of young females depended on the period over which a colony had existed and not on the number of free nest boxes. The studied population had only one brood a year. The synchronisation of the beginning of breeding by particular females was very great. The period of egg-laying was divided into two parts: the basic period and the supplementary one. The basic period, when over 80% of eggs was laid in a given year, was relatively short and the intensity of egg-laying was high. Females laying their first clutches in a given year laid in that period. The supplementary period was relatively long and the intensity of egg-laying was low. In that period delayed clutches were laid and replacement clutches after the loss of the first ones. The young females laid eggs on average 1.5 day later than the old ones. In the basic period the mean size of a clutch was 4.8 eggs. It was smaller for young females than for older ones and it decreased towards the end of the breeding season. In the basic period the mean number of nestlings hatched in one nest was 4.3, whereas the number of fledged young was 3.4 and 3.8 (in different years).

M. Gromadzki, Ornithological Station, Institute of Zoology, Polish Academy of Sciences, 80–680 Gdańsk 40, Poland.

Размножение скворца *Sturnus vulgaris* на Вислинских Жулавах.

Степень использования скворцами скворечников зависит от того, как они развешены и от возраста колонии. К размножению приступают самки на втором календарном году жизни и старшие: количество молодых самок зависит от возраста колонии, а не от количества свободных скворечников. Исследованная популяция выводит только один выводок в год. Синхронизация в приступлении к размножению очень значительна между отдельными самками. Период откладывания яиц можно разделить на две части: основной период и период дополнительный. На протяжении

основного периода птицы откладывают свыше 80% яиц в данном году, период этот отличается компактностью во времени и высокой интенсивностью откладки яиц. В этот период сносят яйца все самки откладывающие свои первые кладки в данном году. Дополнительный период относительно растянутый, интенсивность откладки яиц невысокая. В этот период происходят запоздалые кладки и повторные, после потери первых. Молодые самки откладывают яйца в среднем на 1.5 дня позже старших. Средняя величина кладки в основном периоде составляет 4.8 яйца. Величина эта меньше у молодых самок, а также уменьшается с течением гнездового периода. Среднее число вылупившихся птенцов составляет 4.3 на одно гнездо в основном периоде, а число птенцов, покидающих гнездо 3.4 и 3.8 (в разные годы).

INTRODUCTION

It has been the objective of the present paper to study certain aspects of the reproduction of the starling in Żuławy Wiślane (Vistula Delta Lowland), particulary the age structure of females taking part in reproduction, the process of egg-laying, clutch sizes and also the success of breeding and hatching.

This paper is one of the studies in a series devoted to investigations on the significance of the starling in agrocoenoses in Żuławy Wiślane*. The material for this study was collected in 1971–1974.

Determining the part a given animal population plays in a definite biological system must be preceded by a study of the structure of this population, and reproduction is an important element of that. When estimating reproduction it is essential to know not only the number of offspring of a female, but also the age at which females begin to reproduce (Trojan 1975).

Population parameters connected with the reproduction of birds demonstrate variability according to geographical and ecological factors (Klomp 1970, Immelmann 1971) and values of these parameters recorded for one population should not be generalized to others. This study was undertaken because the reproduction of a starling population inhabiting northern Poland had not been investigated before.

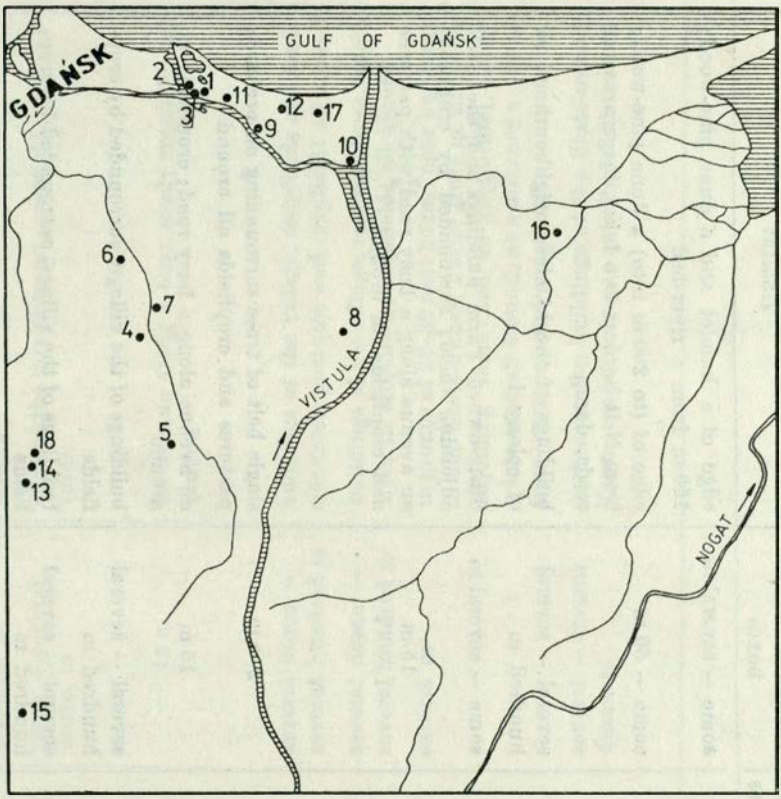
DESCRIPTION OF THE AREA

The investigations involved an area (18°35′E–19°28′E; 54°00′N–54°21′N) situated near the mouth of the Vistula River and, from the north, bordering the Gulf of Gdańsk. Map 1 shows a schematic drafting of the area; there are marked nest box colonies where observations have been carried out. Most of the material has been collected in Żuławy Wiślane; only the following colonies have been situated outside this area: 13, 14 and 18 (Pojezierze Kaszubskie) and 15 (Pojezierze Starogardzkie).

Żuławy Wiślane are a flat, alluvial plains situated not much above sea

* This investigation has been carried out within a PAS project called "Significance of birds in agrocoenoses".

level. The highest point is 11 m above sea level and depressions cover 28 % of the area; 47 % of the area lies from 0 to 5 m above sea level. The soils are mainly muds, peat soils and peat muds. The whole area is covered by a network of numerous rivers, old river-beds, drain canals and ditches — water usually



Map 1. Schematic outline of the study area with marked nest box colonies where the investigations have been carried out. The numbers of colonies correspond to those given in Table 1.

constitutes 4–7 % of the whole area. From the north Żuławy Wiślane are bordered by a belt of dune hills, from several metres to 2 km wide and from several to 30 m high. This area is mostly covered with a forest and is called Mierzeja Wiślana. The remaining part of Żuławy Wiślane is practically without any forest — outside Mierzeja Wiślana this type of covering occupies only 0.6 % of the whole territory. Most part of Żuławy Wiślane is arable land (on the average 77 % of the area) with a large percentage occupied by grasslands.

Pojezierze Kaszubskie is situated 140–330 m above sea level and average heights reach 100–150 m. The area is covered by post-glacial formations, with numerous lakes and rivers. Soils are highly differentiated. Forests cover about 45 % of the territory, the remaining part is mainly arable land.

Table 1. Characteristic of the colonies of nest boxes where observations have been carried out.

No	Name	Date of erecting a colony	Number of boxes	Distances between boxes	Habitat	Inspections
1	Górki Stacja	autumn 1970	50	some – several m	edge of a hamlet and a dune pine-wood; 150 m from a river-bed	repeated
2	Górki Las	autumn 1970 winter 1972	108 37	some – 50 m	edge of (to 200 m into) a dune pine-wood; from N it borders two lakes, large areas of reeds, damp	repeated
3	Górki Osada	spring 1972	32	several – several hundred m	buildings of the hamlet; neighbourhood as of colony 1	repeated
4	Grabina Zameczek	spring 1972	50	some – several m	State-owned Farm buildings and the park adjoining them; surrounded by cropfields	repeated
5	Krzywe Koło	spring 1972	50	15 m	an avenue along a busy road with pastures and cropfields all around	1972 – repeated, following years – once or twice
6	Lendowo	spring 1971	100	2–4 m	single belt of trees surrounding an orchard; pastures and cropfields all around	repeated
7	Lendowo Droga	spring 1971	50	15 m	an avenue along a busy road; cropfields all around	repeated
8	Leszkowy	spring 1972	40	several – several hundred m	buildings of the village, surrounded by cropfields	once or twice
9	Pastwa	spring 1972	6	several – several hundred m	buildings of the village, surrounded by cropfields	once or twice
10	Przegalina	spring 1972	75	some – several dozen m	in groups of 25–30 nest boxes near buildings and in trees on the Dead Vistula; pastures and cropfields all around	1972 – repeated in other years – once or twice

11	Sobieszewo Las	spring 1972	59	some — 30 m	in groups of 3–20 nest boxes at the edges of the forest, pastures and cropfields	repeated
12	Sobieszewo Osada	spring 1972	107	some — several hundred m	buildings of the hamlet, of detached-house nature	repeated
13	Sobowidz Las	spring 1972	50	some — several dozen m	edge of the mixed forest, cropfields and pastures	1972 — repeated, in other years — once or twice
14	Sobowidz Droga	spring 1972	50	15 m	an avenue along a busy road; cropfields all around	1972 — repeated, in other years — once or twice
15	Szpęgawsk	spring 1972 spring 1973	30 30	several dozen — several hundred m	buildings of the village, cropfields and roadside trees; pastures and cropfields all around	once or twice
16	Świerznica	spring 1972	50	several dozen — several hundred m	buildings of the village, roadside trees, single trees in cropfields; cropfields all around	once or twice
17	Wieniec	winter 1971 180 boxes removed in autumn 1973	200	several m	in groups of 25–30 nest boxes: near buildings of the State-owned Farm, trees in the park adjoining them and in cropfields; sandy waste-land all around; at a distance c. 100 m from pastures and cropfields	repeated
18	Żelisławki	spring 1972	45	several — several dozen m	park near the buildings of the State-owned Farm, roadside trees; cropfields all around	1972 — repeated, in other years — once or twice

Pojezierze Starogardzkie is also a post-glacial area, but it is situated lower and has a less rugged surface. Forests cover c. 30 % of the territory.

The climate of the study area is varied and is strongly influenced by the sea. Spring is late and cool. A great changeability of the weather, both overnight and from year to year, is characteristic of the area. Relative humidity is high. Strong, cold north and north-westerly winds very often blow. Temperature variations depend on the distance from the sea. The annual precipitation is 550 mm on average. The above data have been taken from collective studies edited by MONIAK (1974) and AUGUSTOWSKI (1976).

Table 1 presents characteristics of the nest box colonies in which observations have been carried out.

METHODS AND DATA

Observations on the course of hatching involved nests built by starlings in nest boxes. Nest boxes were fixed to trees, at 3.5–4 m, with the entrance facing the east or south-east.

Collecting data in the field. Observations were carried out by means of examinations of nest boxes, usually in the early morning. After a cautious lifting of a side of a box it was checked whether there was a bird there. If no incubating bird was there, the box was opened and its contents inspected. The number of eggs was recorded (and, if possible, whether they were cold or warm) together with the number of alive and dead nestlings.

If there was a bird in the nest, the box was carefully shut and then: a) in 1971 the observer waited until the bird left the nest sometimes making it leave by tapping on the tree trunk; b) in the following years the observer carefully withdrew without looking into the nest during that inspection.

In some colonies nest boxes were examined several times, in others – once or twice, usually during ringing of nestlings.

Repeated inspections began about April 20. They were regular when a nest was visited every three days until the fledging period (most of the colonies inspected in 1971 and 1972) or they were irregular. With the latter system, a nest was visited every three days until recording eggs in it for the first time and than regular inspections were stopped. The number of laid eggs was established during night ringing of females (see below) or during the only inspection carried out in the period of incubation. Further inspections occurred: during hatching, in the middle of the nestling period and at its end – when nestlings were ringed.

All boxes which had been examined many times were also inspected after fledgelings had left them, which made it possible to establish the number of nestlings that had died at the end of the nestling period (dead bodies of such nestlings remained in nests).

If an incubating starling female is caught in the nest in the daytime or

is driven away from its opened box, it usually abandons the clutch (KESSEL 1957, LLOYD 1965, SCHNEIDER 1972). The male does not incubate eggs abandoned by the female, but throws them out the nest, sometimes throwing out the whole nest (KESSEL 1957). Therefore, in order to avoid great brood losses, incubating females were caught during the night by means of the method described by BUB (1974).

The **sex** of caught birds was determined on the basis of the colouring of the mandible and the iris, the **age** on the basis of the length of the iridescent part of the throat feathers (KESSEL 1951). The age was defined in calendar years (ZINK 1973), with the following symbols used: "2nd" or "young" for birds in their second calendar year of life and "after 2nd" or "old" for older birds.

Data analysis. While analysing the data the method of the calendar of broods was used. This consists of presenting the fate of particular nests in the form of linear diagrams parallel to the time axis. The period of laying and incubating eggs in a given nest is presented as one line; since the moment of hatching the number of lines is the same as the number of live nestlings. Diagrams of particular nests are arranged according to the dates of the first egg-laing in a given nest.

The **date when the first egg was laid** has been calculated only for those nests where one of the inspections occurred during egg-laying, with the assumption that eggs were laid at one-day intervals (KESSEL 1957, DECKERT 1970, BOGUCKI 1972).

In the case of nests in which the moment of hatching was not recorded, it has been assumed that the **time of incubation** was 12 days considering the day when the last egg was laid to be the first day. This assumption has been based on knowledge of the time of incubation in 90 nests, which was 12.22 days in average. The same mean length of incubation (12 days) for the starling has also been given by other authors (KLUIJVER 1933, WALLRAFF 1953, KESSEL 1957, VON HAARTMANN 1966, BOGUCKI 1972).

In the case of nests where the exact **date of fledging** was not observed, it has been assumed that they stayed in the nest for 20 days (according to different authors, the mean nestling period is 20–22 days; 21 days is the most frequently given number – KESSEL 1957, KARPOVIČ 1962, LLOYD 1965, BOGUCKI 1972).

In the case of nestlings dying in the nest, it has been assumed that, when the date of death was known within two days, the first day was the date of death, and, when the day of death was not known within two days, the mean day between visits was the date of death.

The **mean clutch size** has been calculated on the basis of nests which were considered to contain full clutches. Incubation, regardless of its result or the number of incubated eggs, has been the criterion for a completed clutch. Nests in which eggs were recorded, but no incubation was observed, have not been taken into consideration. The **mean number of nestlings hatching and fledging**

has been calculated on the basis of the number of nests in which at least one nestling hatched. Those nests in which eggs were incubated, but no nestling hatched, have not been taken into consideration. The reason for excluding some nests from the calculations has been brought about by the desire to avoid considerable errors resulting from the method of data collection (as a result of nest inspections some females leave their clutches; clutch losses due to this fact may be considerable, for instance, COLLINS and DE VOS, 1966, have estimated that up to 54 % of the total amount of losses recorded for the period of laying and incubating eggs may be caused when observers disturb birds). It is true that a number of deserted nests may be left by birds because of other factors, not connected with any observer and, therefore, the result of calculations may be higher than the true survival rate of laid eggs. It seems, however, that such a procedure considerably increases the degree of comparability of data collected by different observers and under different habitat conditions (e.g. while collecting data for this study it was observed that starlings deserted their nests more readily when boxes were fixed at short distances and not so readily when boxes were scattered over a larger area. Also, birds deserted their nests more frequently when boxes were fixed in areas often visited by people and not so frequently when boxes were in more isolated places).

The expression **"hatching success"** means the ratio of the mean number of hatched nestlings to the mean clutch size. The expression **"breeding success"** means the ratio of the mean number of fledged young to the mean clutch size.

The identity of variances in particular samples has been estimated by means of BARTLETT's test (ZIELIŃSKI 1972), and the significance of differences between the means has been estimated on the basis of the analysis of variance (BRANDT 1974). In those cases when F_{max} was higher than the critical values for the level of significance 0.05, T-test and DUNCAN's test (PLATT 1974) have been used for further analysis of the significance of differences.

In the case of heterogeneity of variances in particular samples, COCHRAN's and COX's test (OKTABA 1974) has been applied for estimating differences between the means.

The dynamics of egg-laying has been tested by means of the probability

Table 2. Number of inspected nests with at least 1 egg.

Year	Inspected nests		Total
	repeatedly	once or twice	
1971	250	–	250
1972	514	179	693
1973	151	414	565
1974	108	335	443
Total	1023	928	1951

Table 3. Number of females caught on the nest.

Year	Age of females			
	2nd year		after 2nd year	
	Age determined on the basis of		Age determined on the basis of	
	Ringing data	Morphological features	Ringing data	Morphological features
1972	–	63	–	32
1973	8	34	15	85
1974	3	28	31	28
Total	11	125	46	145
	136		191	

paper of the normal distribution (HARDING 1949, TAYLOR 1965, GRIFFITHS 1968, ZAJĄC 1976).

The material has been presented in Tables 2 and 3.

DEGREE OF THE UTILIZATION OF NEST BOXES

Those nests which contained at least one egg were considered to be utilized by starlings (the same criterion was applied by VERHEYEN 1969). To this group boxes with empty nests or unfinished ones or boxes to which males carried flowers and green leaves were not included because, in all the colonies usually 100% and never less than 90% of boxes were occupied in this way. Some of them may have been occupied by pairs which, for some reason, had not started egg-laying, most of them, however, must have been occupied only by males. In several cases it was possible to find out that a male occupied a few (up to 4) closely fixed boxes, although only in one of them a brood had been found. Boxes are occupied not only by breeding adult male birds, but also by young non-breeding males (BERTHOLD 1964, 1966, VERHEYEN 1969).

The fraction of utilized boxes greatly differed in particular colonies (Table 4). Boxes were utilized best when they had been fixed separately or in small groups (3–5 boxes) several hundred metres apart (Pastwa, Szpęgawsk, Świerznica, Sobieszewo Las). The habitat those boxes had been placed in did not play any sigificant part.

Boxes fixed in more or less dense colonies were usually utilized to a smaller degree and it was possible to notice distinct differences depending on the habitat in which boxes had been placed. In this group, the best utilized boxes belonged to those fixed in midfield afforested areas (Krzywe Koło, Lendowo Droga, Lendowo) and on the edge of a forest (Sobowidz Las); the worst utilized

Table 4. Percentage of the utilization of nest boxes in particular colonies. N – number of boxes in a colony, % – percentage of utilized boxes, M – colony penetrated by the marten – *Martes* sp., S – colony penetrated by the squirrel – *Sciurus vulgaris*.

Colony	1971		1972		1973		1974	
	N	%	N	%	N	%	N	%
Górki Stacja	50	42	50	49	50	36 M	49	35 M
Górki Las	108	71	146	60	143	50 M	143	22 M
Górki Osada	–	–	25	44	32	44	13	77
Grabina Zameczek	–	–	50	50	29	83	40	53
Krzywe Koło	–	–	46	72	36	89	32	59
Lendowo	100	69	100	70	99	90	86	92
Lendowo Droga	50	64	50	56	36	94	35	60
Leszkowy	–	–	34	47	–	–	18	44
Pastwa	–	–	6	83	6	100	6	100
Przegalina	–	–	71	58	35	86 M	39	28 M
Sobieszewo Osada	–	–	107	55	94	61	92	47
Sobieszewo Las	–	–	59	81	54	69 M	50	62 M
Sobowidz Las	–	–	50	72 M	47	81	26	73
Sobowidz Droga	–	–	50	62	31	71 M	20	45 M
Szpęgawsk	–	–	31	100	38	100	61	44 M
Świerznica	–	–	49	88	39	90	–	–
Wieniec	141	31	124	40	–	– M	20	50 M
Żelisławki	–	–	45	47	–	– S	38	24 S

Table 5. Dependence of the degree of box utilization (%) on the time of a colony existence.

Kind of a colony	Time of a colony existence			
	1st year	2nd year	3rd year	4th year
separate boxes	90	97	72	–
boxes in groups (without boxes from Lendowo)	58	68	48	36
boxes from Lendowo	69	70	90	92

ones were those in hamlets (Leszkowy, Sobieszewo Osada, Górki Osada). Similarly, VERHEYEN (1969a) has recorded that in Belgium the percentage of box utilization is the lowest in colonies situated near human settlements. It is interesting that in the study area over a half of the starling population nested in roofs

of houses, even forming small colonies that reached up to 21 nests in one roof (GROMADZKI 1978). Such a density of nests was never reached by fixing nest boxes very close to one another.

Boxes erected in dense colonies in sandy, littoral areas of Żuławy were utilized less frequently (48 % on the average) than those in areas with loamy soil (64 % on the average).

Boxes were utilized differently in particular years of the existence of a colony, and there occurred differences according to the manner of their distribution and the habitat (Table 5). In most colonies the highest degree of utilization occurred during the second, and less frequently in the first year that a given colony existed. The reason for better utilization in the second year may have been due to their being fixed late in the spring, at the beginning of April. Starting with the third year there appeared a decrease, becoming more distinct in the fourth year. This occurred even though boxes were more dispersed because many had been destroyed by people. In some cases it was possible to connect the decrease with a penetration of a given colony by predators, but in others the reason had not been discovered (e.g. Sobieszewo Osada). The colony in Lendowo was exceptional because there the degree of box utilization constantly increased from year to year. This case is difficult to explain because, although no predators were recorded destroying nests there, people caused considerable nest losses — both as a result of the investigations and the activity of members of the public.

In some cases (e.g. Górki Osada, Table 4) an increase in the degree of box utilization in the third year resulted from a considerable decrease in their number in a given colony.

AGE OF BREEDING FEMALES

It has been found out that in the study area both young females (in the second calendar year of life) and older ones (over two years) took part in breeding (Tables 3 and 6). The participation of these two groups was different and it depended on the length of time a colony had existed. In the first year of the existence of a colony (Table 6) more young females were recorded. In particular colonies the ratio of young females to older ones varied from 1.4 to 4.0, 2.0 on the average. Such a situation occurred both when a newly-founded colony was far from where starlings had nested previously (e.g. Sobowidz Droga) and when they had nested fairly close to it in great numbers (e.g. Przegalina).

In the second, or further years of the existence of a colony the situation changed and older females constituted the more numerous group. This phenomenon was most distinct in 1973 when in 5 colonies, investigated in this respect, only one presented more younger females and in the others the relation of the number of older females to younger ones varied from 2 to 4; in one colony only old females nested. In 1974 these proportions were shaked or reversed in two

Tabela 6. Participation in breeding of females of different ages.

Colony		Participation in breeding of females of different ages					
		1972		1973		1974	
Date a colony was founded	Name	2nd year	after 2nd year	2nd year	after 2nd year	2nd year	after 2nd year
autumn 1970	Górki Stacja	–	–	0	13	9	4
spring 1971	Górki Las	–	–	6	18	4	5
	Lendowo	–	–	27	56	15	44
spring 1972	Górki Osada	–	–	2	8	3	6
	Krzywe Koło	14	9	–	–	–	–
	Przegalina	22	11	–	–	–	–
	Sobieszewo Las	–	–	7	5	–	–
	Sobowidz Droga	16	4	–	–	–	–
	Żelisławki	11	8	–	–	–	–
Total		63 (66%)	32 (34%)	42 (30%)	100 (70%)	31 (34%)	59 (66%)

colonies (Górki Las and Górki Stacja) where, beginning with 1973, a considerable number of incubating females were destroyed by the marten – *Martes* sp. In the other two colonies, where the marten did not prey, the advantage was on the side of old incubating females.

In the literature there is an opinion that the age at which starlings reach sexual maturity and start breeding is geographically variable, as one moves from west to east and from south to north the percentage of young breeding birds decreases. A compilation of data from the literature dealing with this problem has been made by BERTHOLD (1964). BERTHOLD has made a map of the distribution in Europe of places where nesting of young starlings has been recorded; apparently the map confirms the above-mentioned thesis, but after a closer examination there appear some doubts. He has not taken into consideration data from the Russian literature which provides basic evidence contradicting his theory (POLIVANOV 1957, KARPOVIČ 1962). In another paper BERTHOLD (1969) reports that in the south-westen part of F. R. G. young females constitute 24–29% of all nesting females; this percentge is even slightly lower than the one recorded in Żuławy Wiślane (Table 6).

BERTHOLD (1964) has demonstrated experimentally that the time of reaching sexual maturity (by both females and males) is not conditioned genetically, but depends on external factors. The extent of migration of a given population is considered by him to be the main one. However, there is evidence

indicating that other factors may also be important. POLIVANOV (1957) has reported that the breeding of young females depends on the accessibility of places convenient for building a nest: with an overabundance of nesting places participation was up to 50%. When a given area lacked such places it did not exceed 19%.

Facts given in the present paper show that the problem of whether young females breed or not may also be influenced by the appearance in the habitat of a new attractive element (e.g. new nest box colony) or a considerable reduction of older individuals. In the case of a new colony of nest boxes it is not entirely the question of free places for nest building because in normal existing colonies a great percentage of boxes remains non-utilized, even increasing with time (it therefore contradicts the above-mentioned statement of POLIVANOV, 1957). Therefore, a population reacts to a created possibility of taking possesion of a new element of the habitat not by making the existing density lower, but by including into breeding an additional number of individuals. This phenomenon is similar to the process of including into the breeding group, when some individuals belonging there have been eliminated, a number of other individuals forming a population reserve. Such behaviour has been recorded in many bird species (VON HAARTMANN 1971) and rodents (BUJALSKA 1971). However, it has not been discovered whether young starling females belong to a population reserve (in the meaning of the expression as used by V. HAARTMANN, 1971) or whether habitat factors influence the accelaration of the maturing process.

EGG-LAYING

The process of egg-laying has been examined for 1971 and 1972. Data collected in all the investigated colonies have been analysed together.

In both years the first eggs were laid on 24.04 (Figs. 1 and 2); on the following days the number of laid eggs kept increasing considerably until a rapid decrease in the first days of May. In the following period egg-laying was not very intensive and it lasted until the end of May (1971) or the first days of June (1972).

During both years the period of egg-laying was distinctly divided into two parts, called the basic and supplementary periods. The dividing line between these periods has been calculated on the basis of the course of the dynamics curve of the beginning of egg-laying. One of the minima of the curve was considered the limiting point: in 1971 the minimum from May 6, in 1972 — May 4-5. As a result of this those clutches in which the first egg was laid before the above dates are included into the basic period, and clutches started during those days or later in to the supplementary period.

Most females began egg-laying during the basic period though it was relatively short. At first the number of females beginning egg-laying increased rapidly (Figs. 1A, 2A), then it decreased more slowly (1971) or more quickly

(1972). This was accompanied by an intensive increase in the number of eggs laid daily and after it had reached its maximum it decreased equally rapidly (Figs. 1B, 2B). The curve of the dynamics of egg-laying is monomodal, similar to the normal one.

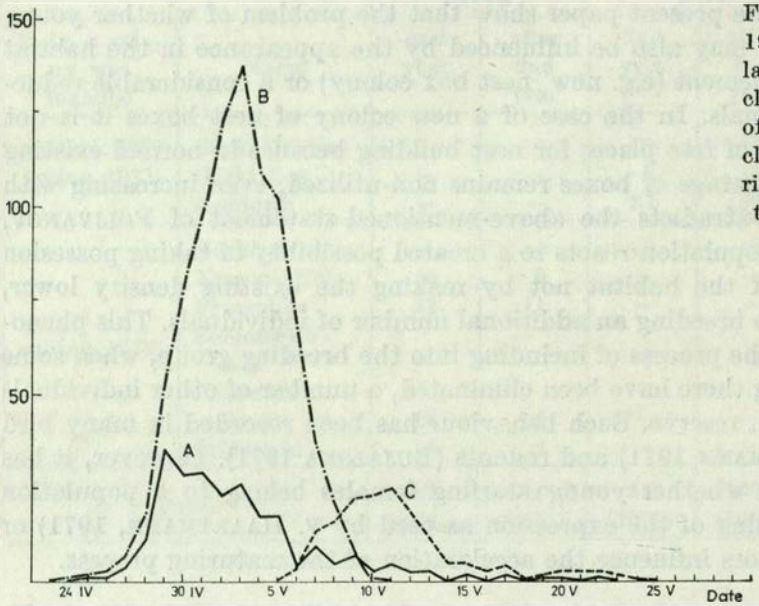


Fig. 1. Egg-laying in 1971. A – dynamics of laying the first eggs in a clutch; B, C – dynamics of laying all eggs from clutches of the basic period and the supplementary one, respectively.

The supplementary period was characterized by a considerably lower intensity of egg-laying and lasted fairly long. During the following days only a few females began egg-laying (Figs. 1A, 2A). The total number of eggs laid daily was also rather low (Figs. 1C, 2C) and the curve of its dynamics was a multimodal one.

An analysis of the percentage cumulative frequencies of the dynamics of the beginning of egg-laying (Fig. 3) makes it possible to draw the following conclusions:

– dates when egg-laying began in the studied populations do not have the normal distribution (Fig. 3A); distinct inflexions of the curves (in 1971 on a level of c. 80%, in 1972 – c. 90%) suggest that the studied clutches do not constitute a homogeneous group;

– dates of the beginning of egg-laying in the clutches of the basic period have a normal distribution (Fig. 3B; verification of the hypothesis of a normal distribution has been made by means of a graphic method, ZAJĄC 1976), which proves a high homogeneity of the clutches of that period;

– dates of the beginning of egg-laying in the clutches of the supplementary period do not have a normal distribution (Fig. 3C), and the inflexions of the curves suggest that the clutches of that period are not a homogeneous group. One may assume that this group consists of clutches of females laying their

delayed eggs and of clutches of females laying eggs for the second time, after their first nest had been destroyed. Assuming that the percentage of both groups is determined by the point of inflexion makes it possible to estimate the percentage of delayed and replacement clutches: the former constituted

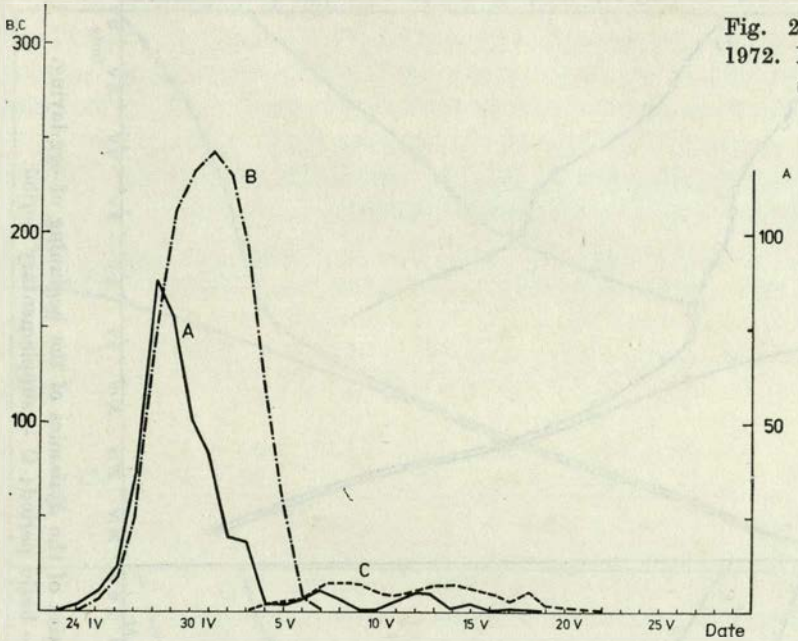


Fig. 2. Egg-laying in 1972. For explanations see Fig. 1.

about 80 % of the clutches of the supplementary period in 1971 and about 45 % in 1972, i.e., 16 % and c. 5 %, respectively, of all the clutches of the given year, the replacement clutches — 4 % and 6 %, respectively, of all clutches. The accepted manner of calculating the percentage of replacement clutches in the total number of clutches does not take into consideration the fact that a certain number of these clutches may have been started before the date of the point of inflexion. Therefore, it should be kept in mind that the estimate obtained of the percentage of replacement clutches may be a little too low. It seems, however, that this error is not too great because it has been found that the period of time between deserting a nest and the beginning of egg-laying for the replacement clutch is considerable (on the average 14.5 days, minimum 10 days, N = 6). When considering the problem of repeated egg-laying, it should be remembered that irregularities in the course of breeding of the studied population were, to a considerable degree, due to the investigation itself. In an undisturbed population, these irregularities — desertion and replacement clutches — happen more seldom.

The dates of laying of all eggs (Fig. 4) in the basic period have a normal distribution. In the clutches of that period 84 % in 1971 and 90 % in 1972 of all eggs were laid. The repeated clutches constituted on average about 4.5 % of the total of eggs laid, a number insignificant for the production success.

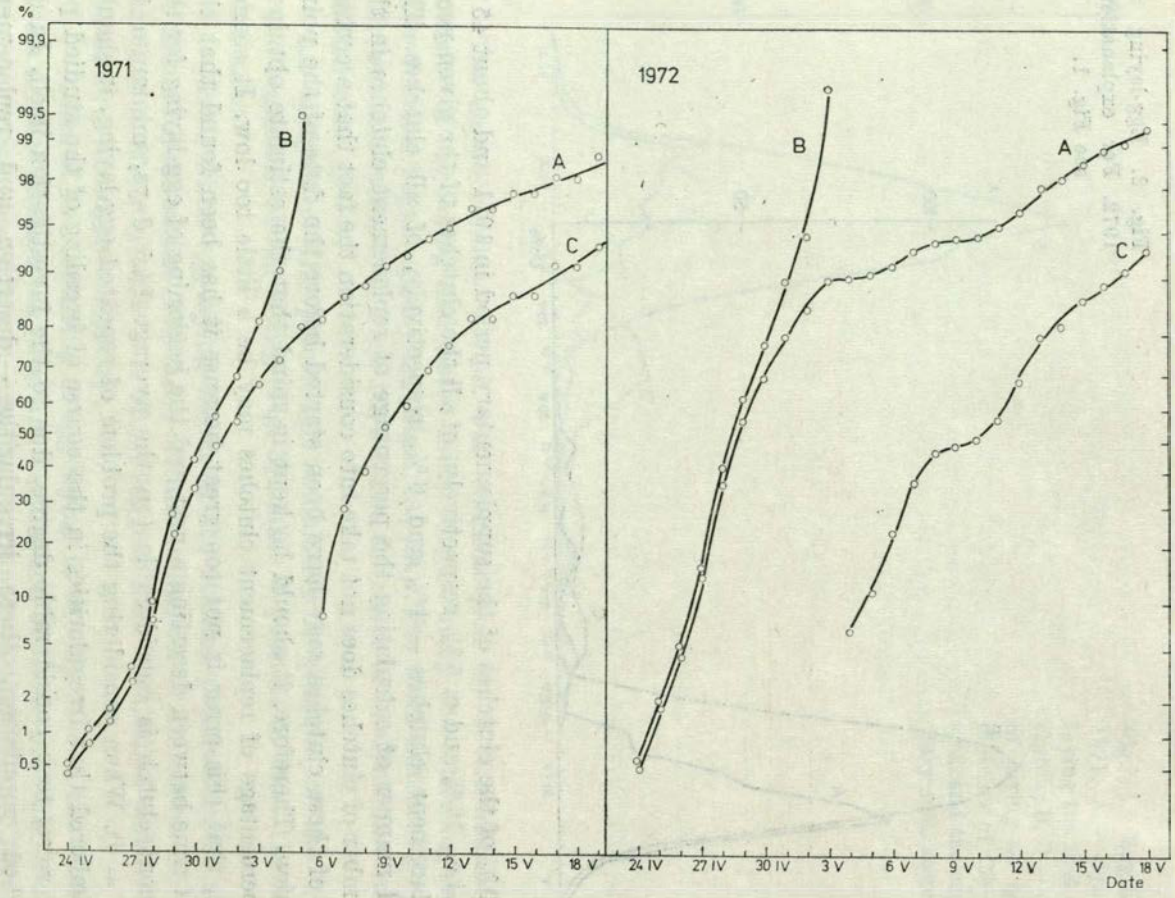


Fig. 3. Percentage cumulative frequencies of the dynamics of the beginning of egg-laying. A — whole period of laying; B — basic period; C — supplementary period.

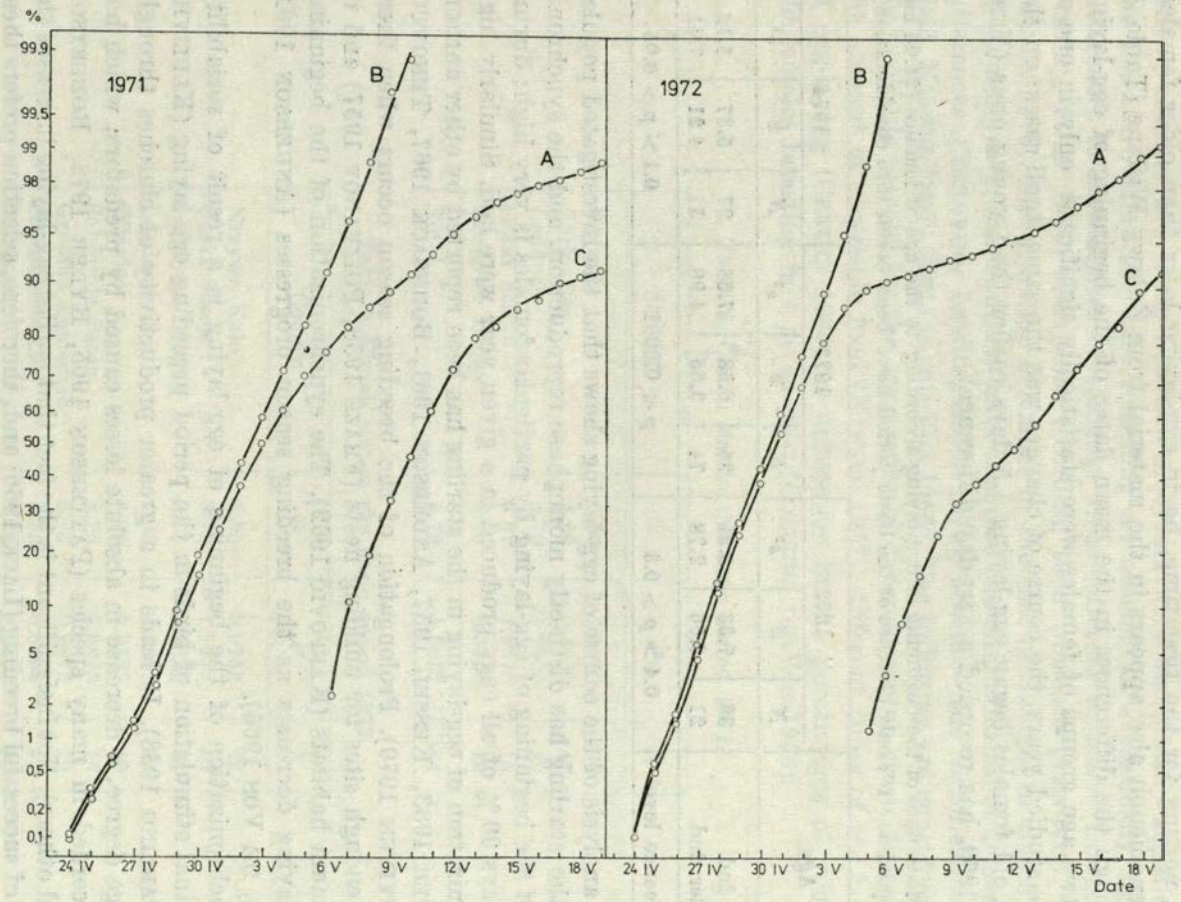


Fig. 4. Percentage cumulative frequencies of the dynamics of laying all eggs. For explanations see Fig. 3.

The average data of egg-laying for clutches in the basic period fell on May 3 in 1971 and May 1 in 1972 (Fig. 4).

Both in the case of the starling (KLUIJVER 1933, WALLRAFF 1953, VERHEYEN 1969) and other birds (KLOMP 1970) it has been recorded that young females, nesting for the first time, begin egg-laying later than older females. This phenomenon also appears in the material from Żuławy Wiślane (Table 7) and, though the differences in the mean dates of the beginning of egg-laying by the two age groups of females were statistically significant only in one of the three studied years, the course of changes was the same in all cases: on the average, old females began egg-laying 1.5 days earlier than young ones (VERHEYEN, 1969, has recorded a two-day difference).

Table 7. Mean date of the beginning of egg-laying according to the age of females (24.04 has been accepted as "1"; only clutches of the basic period have been taken into consideration).

Age	1972			1973			1974		
	N	$\bar{x}$	s^2	N	$\bar{x}$	s^2	N	$\bar{x}$	s^2
2nd	36	7.33	5.21	26	6.58	7.58	27	5.37	5.12
after 2nd	21	6.66	2.78	74	3.65	4.98	57	4.21	7.51
Significance level	$0.4 > p > 0.3$			$p < 0.0001$			$0.1 > p > 0.05$		

An analysis of the course of egg-laying shows that the investigated population of the starling has distinctly monophase reproduction, and the synchronization of the beginning of egg-laying by particular females is very high: during 12–16 days 90 % of all eggs produced in a given year were laid. Similarly high synchronization of egg-laying in the starling has been reported by other authors (KLUIJVER 1933, KESSEL 1957, ANDERSON 1961, BOHNSACK 1967, TENOVUO, LEMMETYINEN 1970). Prolongation of the breeding season occurs when there are not enough sites for building nests (FRAZE 1938, POLIVANOV 1957) and in suboptimum habitats (KARPOVIČ 1962). The synchronization of the beginning of egg-laying decreases as the breeding season progresses (ANDERSON 1961, COLLINS, DE VOS 1966).

Synchronization of the beginning of egg-laying is a result of sociability and mutual stimulation of birds in the period preceding egg-laying (KLUIJVER 1933, DARLING 1938). It leads to a greater productivity of clutches through, to a large degree, a decrease in absolute losses caused by predators, which has been recorded in many species (PATTERSON 1965, RYDER 1972, ROBERTSON 1973 and others). Not insignificant is the fact that earlier egg-laying increases the chances of successful breeding (LACK 1966) and, therefore, selection prefers these females which may start breeding as soon as habitat conditions make it possible. There are data indicating that starling females laying eggs later, are weaker or less experienced individuals (WAGNER et al. 1965, CAVE 1968). Lack of experience may be the reason why young females start egg-laying later.

CLUTCH SIZE

The mean cluth size during the basic season varied in particular colonies and in both years from 4.5 to 5.5 (Tables 8 and 9), but neither the differences among colonies nor those between the years were statistically significant. In the literature there are data recording an absence of statistically significant differences in clutch sizes of starlings from different habitats (LUNIAK 1977, PIKULA, FOLK 1970) and those recording their presence (TENOVUO, LEMMETYINEN 1970). The situation is similar in the case of changes in clutch sizes in particular years: some authors have reported the insignificance of demonstrated differences (TENOVUO, LEMMETYINEN 1970), others – the significance (LACK 1948, KESSEL 1957, COLLINS, DE VOS 1966). The following are considered to be the probable reasons for the occurrence of different clutch sizes: differences in the amount of accessible food (KESSEL 1957), different times of the beginning of egg-laying (CREUTZ 1939) or differences in the percentages of young and old females breeding in a given year (COLLINS, DE VOS 1966).

Table 8. Clutch size in the basic period 1971.

Colony	$\bar{x}$	s^2	N
Wieniec	5.00	0.6000	30
Górki Las	4.89	0.6032	47
Lendowo	4.70	1.2900	50
Górki Stacja	4.67	1.9678	18
Lendowo Droga	4.58	0.3458	19
Total	4.79	1.0057	164

Table 9. Clutch size in the basic period 1972.

Colony	$\bar{x}$	s^2	N
Krzywe Koło	5.55	0.9755	22
Górki Stacja	5.11	1.1471	19
Lendowo Droga	5.11	0.9532	28
Lendowo	4.98	1.0537	56
Wieniec	4.98	0.8327	42
Sobowidz Szosa	4.75	0.6875	16
Grabina Zameczek	4.75	0.9875	20
Sobieszewo Las	4.72	0.6664	43
Żelisławki	4.71	0.6803	21
Przegalina	4.65	1.0518	17
Górki Las	4.61	1.0115	62
Sobieszewo Osada	4.49	0.7205	51
Total	4.83	0.9507	397

Table 10. Clutch size in the supplementary period and the mean numbers of hatched nestlings and fledged young in nests of that period (significance of differences calculated in relation to corresponding means of the basic period).

Parameter	Year	$\bar{x}$	s^2	N	Significance level
Clutch size	1971	4.21	1.1045	34	$p < 0.05$
	1972	4.04	1.0547	55	$p < 0.001$
Number of hatched nestlings	1971	3.70	1.2191	33	$p < 0.05$
	1972	3.41	0.9667	37	$p < 0.001$
Number of fledged youngs	1971	2.91	2.1986	33	$p < 0.002$
	1972	2.58	1.9289	38	$p < 0.001$

The mean clutch sizes of the supplementary period were, in both years, lower than the means of the basic period (Table 10).

Dependence of the clutch size on the date of the beginning of egg-laying appears not only when clutches of the basic and supplementary periods have been separated, but also when these periods have been divided into shorter periods of time. Clutches begun during successive periods of the basic period were smaller and smaller (Tables 11 and 12). During the supplementary period the course of changes in clutch sizes was different in both years (Tables 11 and 12).

Table 11. Dependence of the clutch size on the date of laying the first egg in a clutch 1971.

	Date of laying the first egg	N	$\bar{x}$	s^2	Significance level
Basic period	24.04–29.04	49	5.24	1.1342	$p < 0.01$
	30.04–02.05	76	4.70	0.6600	$p < 0.05$
	03.05–05.05	55	4.35	0.7320	
Supplementary period	06.05–08.05	16	4.56	1.0189	$p > 0.05$
	09.05–11.05	10	4.10	0.4900	$p > 0.05$
	12.05–20.05	7	3.86	1.8147	

Table 12. Dependence of the clutch size on the date of laying the first egg in a clutch 1972.

	Date of laying the first egg	N	$\bar{x}$	s^2	Significance level
Basic period	24.04–26.04	19	5.63	0.7768	$p < 0.01$
	27.04–29.04	187	4.99	0.8004	$p < 0.01$
	30.04–02.05	102	4.41	0.9833	
Supplementary period	03.05–05.05	18	3.50	0.6944	$p < 0.01$
	06.05–08.05	13	4.00	1.0769	$p < 0.01$
	09.05–20.05	20	4.40	0.5400	

Table 13. Dependence of the clutch size on the age of a female.

Year	Age group	$\bar{x}$	s^2	N	Significance level
1972	2nd	4.60	0.9858	48	–
	after 2nd	4.56	1.1264	25	
1973	2nd	4.12	0.6767	42	$p < 0.001$
	after 2nd	4.82	0.7379	101	
1974	2nd	4.35	1.0390	26	$p < 0.05$
	after 2nd	4.84	1.0665	63	
Total	2nd	4.40	0.6961	116	$p < 0.001$
	after 2nd	4.79	0.9289	189	

The reason of this is not known. A constant decrease in the mean clutch size occurring as the breeding season progresses has been reported for the starling by all investigators studying this problem, and, since this phenomenon has been recorded for other species as well, it may be considered a general fact (KLOMP 1970).

Young females usually laid fewer eggs than old ones (no dependence of the clutch size on the age of a female occurred in one of the three studied years, Table 13). The same fact has been recorded, for the starling, by other authors (KLUIJVER 1933, 1935, KESSEL 1957, COLLINS, DE VOS 1966), but it has also been recorded for many other bird species (KLOMP 1970).

NUMBER OF HATCHED NESTLINGS

In 1971 the mean number of nestlings hatched in one nest varied in particular colonies from 3.8 to 4.9 – the two highest means differed considerably from some of the others (Table 14).

In 1972 the mean number of nestlings hatched in one nest varied from

Table 14. Mean number of nestlings hatched in nests of the basic period 1971.

Colony	N	$\bar{x}$	s^2
Wieniec	27	4.85	0.6652
Górki Stacja	17	4.59	1.6559
Górki Las	37	4.27	1.2295
Lendowo Droga	19	4.16	0.5521
Lendowo	45	3.76	1.8378
Total	145	4.24	1.4500

Significance levels:
Wieniec – Górki Las: $p < 0.05$;
Wieniec – Lendowo Droga: $p < 0.01$;
Wieniec – Lendowo: $p < 0.01$;
Górki Stacja – Lendowo: $p < 0.05$.

3.9 to 5.0 in particular colonies, differences were not statistically significant (Table 15). The general means were the same in both years.

The mean number of nestlings hatched in clutches of the supplementary period were, in both years, distinctly lower than the mean number of nestlings hatched in clutches of the basic period (statistically significant differences, Table 10).

Table 15. Mean number of nestlings hatched in nests of the basic period 1972.

Colony	$\bar{x}$	s^2	N
Górki Stacja	5.00	1.1764	17
Lendowo Droga	4.58	1.5519	26
Wieniec	4.38	1.1884	42
Sobieszewo Las	4.32	0.8220	37
Lendowo	4.15	1.0151	52
Sobieszewo Osada	4.09	1.1660	46
Górki Las	4.02	1.4248	47
Grabina Zameczek	3.90	1.5900	20
Total	4.25	1.2536	287

In nests of the basic period the modal numbers of nestlings hatched in the nest were 4 (1972) and 5 (1971); in both years clutches consisting of 4–5 eggs constituted 65–70% of the total of nests. 8 hatched nestlings recorded in one nest were the maximum (9 nestlings in one nest were sometimes recorded in other years).

In nests of the supplementary period the most frequently recorded number was that of 4 hatched nestlings in one nest, nests with three nestlings came second.

NESTLING PERIOD AND THE SURVIVAL RATE OF NESTLINGS

In 1971 the first nestlings hatched on May 11 and in 1972 on May 10.

In the nestling period three sub-periods may be distinguished varying in respect of the number of nestlings (Fig. 5). The first is the sub-period of mass hatching when nestlings hatched in many nests at the same time and their number increased rapidly from day to day; that period lasted for 13 and 5 days. Then followed a period of the growth of nestlings (11 and 15 days) when their number was at a more or less stable level and its slight fluctuations were due to nestling mortality and hatching in a few delayed nests. The last was the period of nest leaving when the number of nestlings staying in the nest decreased rapidly from day to day. Most fledglings left the nest in the first ten days of June.

The survival rate of nestlings was higher in nests of the basic period than in those of the supplementary one (Table 16), but greater survival differences

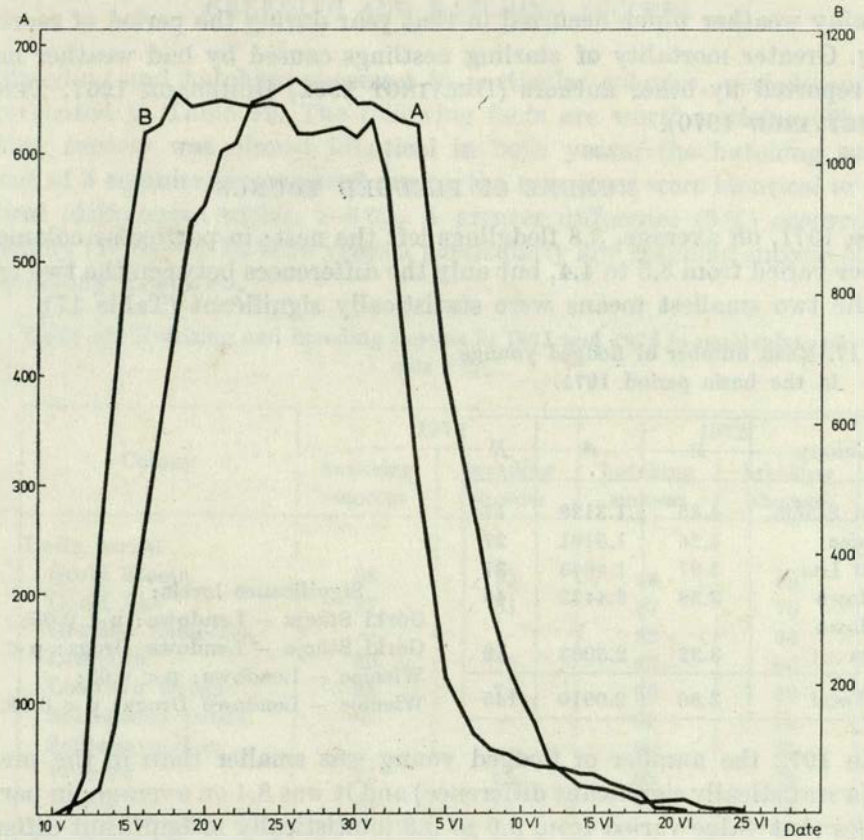


Fig. 5. Number of alive nestlings found in the nest on a given day. A — year 1971; B — year 1972.

occurred between the years than between the periods during one year. In 1972 the mortality of nestlings was considerably higher than in 1971, which was first of all connected with a more frequent disappearance of older nestlings, in the third or even fourth age class. This was undoubtedly caused by cold

Table 16. Percentage of nestlings outliving a certain period of time (the number of hatched nestlings has been considered 100%).

Period	Year	Days of life			
		1–5	6–10	11–15	16–20
basic	1971	95	91	89	89
	1972	91	86	81	80
supplementary	1971	92	86	84	84
	1972	91	87	79	77

and rainy weather which occurred in that year during the period of rearing the young. Greater mortality of starling nestlings caused by bad weather has also been reported by other authors (DELVINGT 1962, BOHNSACK 1967, TENOVUO, LEMMETYINEN 1970).

NUMBER OF FLEDGED YOUNGS

In 1971, on average, 3.8 fledglings left the nest; in particular colonies that number varied from 3.3 to 4.4, but only the differences between the two greatest and the two smallest means were statistically significant (Table 17).

Table 17. Mean number of fledged youngs in the basic period 1971.

Colony	$\bar{x}$	s^2	N
Górki Stacja	4.35	1.3128	17
Wieniec	4.26	1.5191	27
Górki Las	3.97	1.5643	37
Lendowo	3.38	2.4423	45
Lendowo Droga	3.32	2.5063	19
Total	3.80	2.0910	145

Significance levels:
Górki Stacja – Lendowo: $p < 0.05$;
Górki Stacja – Lendowo Droga: $p < 0.05$;
Wieniec – Lendowo: $p < 0.05$;
Wieniec – Lendowo Droga: $p < 0.05$.

In 1972 the number of fledged young was smaller than in the preceding year (a statistically significant difference) and it was 3.4 on average; in particular colonies that value varied from 3.0 to 3.8 (statistically insignificant differences, Table 18).

Table 18. Mean number of fledged youngs in the basic period 1972.

Colony	$\bar{x}$	s^2	N
Wieniec	3.76	2.4214	42
Sobieszewo Las	3.62	1.3124	37
Górki Stacja	3.53	1.3635	17
Sobieszewo Osada	3.33	2.5270	46
Lendowo	3.31	1.3677	52
Górki Las	3.23	1.4336	47
Lendowo Droga	3.15	2.5885	26
Grabina Zameczek	3.05	2.0500	20
Total	3.39	1.9167	287

In both years the mean number of fledged young was considerably lower in nests of the supplementary period than in those of the basic period (Tab. 10) – differences between years were insignificant in the supplementary period.

BREEDING AND HATCHING SUCCESS

Breeding and hatching successes in particular colonies, periods and years are presented in Table 19. The following facts are worth noticing. The mean hatching success was almost identical in both years; the hatching successes in 4 out of 5 colonies investigated during the two years were identical or almost identical (differences within 1–3 %). A greater difference (9 %) occurred only in 1 colony (Wieniec). In both years a particularly low hatching success occurred in the colony Lendowo.

Table 19. Hatching and breeding success in 1971 and 1972 in particular colonies (%).

Colony	1971		1972	
	hatching success	breeding success	hatching success	breeding success
Basic period				
Górki Stacja	98	93	98	69
Górki Las	87	81	87	70
Grabina Zameczek	–	–	82	64
Lendowo	80	72	83	66
Lendowo Droga	91	72	90	62
Sobieszewo Osada	–	–	91	74
Sobieszewo Las	–	–	92	77
Wieniec	97	85	88	76
Total	89	79	88	70
Supplementary period in all colonies	88	69	84	64

The mean breeding success was 9 % lower in 1972 than in 1971 and the breeding success in all the colonies was also lower. As already mentioned, this was probably due to bad weather.

Hatching and breeding success in nests of the supplementary period were, in both years, lower than in nests of the basic period which agrees with the fact recorded by other authors that these parameters decrease as the breeding season progresses (LACK 1948, KESSEL 1957, ANDERSON 1961, HAVLIN, FOLK 1961, JOHNSON et al. 1974 and others). Breeding success in nests of the supplementary period is of little significance for the total productivity of the studied population: on the average 6.5 % of the total production of the young in a given year came from these nests.

In both years the lowest breeding successes occurred in the same group of colonies – Lendowo, Lendowo Droga and Grabina Zameczek, the only ones among the studied colonies which were situated in an agricultural setting typical of Żuławy. At the same time there were colonies with a very high degree of the utilization of nest boxes and, therefore, highly attractive for starlings.

A possible reason for such a situation may have been a negative influence of density on the reproduction of the starling, which has experimentally been demonstrated by RISSER (1975).

Differences in the breeding success in the two years occurred though in both years the initial value – the mean clutch size, had been almost identical.

CONCLUSIONS AND RECAPITULATION OF RESULTS

1. The degree of the utilization of nest boxes depended on the manner of their fixing. It was higher for boxes fixed separately or in small groups (the kind of habitat did not play any significant part in this case) and lower for boxes erected in colonies (in this case the influence of the habitat in which boxes were fixed was visible).

2. The degree of the utilization of nest boxes depended on the time a colony had existed: it was highest in the first or second year and then it distinctly decreased (one colony was an exception).In most cases the reason had not been discovered.

3. Young females in their second full summer and older ones took part in breeding. The percentage of young females depended on the length of time a colony had existed and in the first year it was 66 %, in successive years about 30 %. It seems that situation was not caused by overabundance of places for nests, but by the erecting of new nest boxes in the habitat. The percentage of young females – among all those that start breeding – increased also when older females had been considerably reduced by predators.

4. The studied starling population completed only one brood a year and the synchronization of the beginning of egg-laying by particular females was very great.

5. The period of egg-laying was divided into two distinctly separate parts called the basic period and the supplementary period. The basic period was short, characterized by high intensity of egg-laying and during that period were laid over 80 % of eggs laid in a given year. Females laying in that period laid their first clutches in a given year. The supplementary period was longer, characterized by low intensity of egg-laying. In that period delayed and replacement clutches were laid the latter represented about 4.5 % of eggs laid in a given year.

6. On average, young females began egg-laying 1.5 days later than old ones.

7. For calculating the mean size of a clutch only the data collected in nests where incubation was recorded has been used. The mean numbers of hatched nestlings and fledged young have been calculated entirely on the basis of data collected in nests where at least one nestling hatched. With such assuptions, results of calculations may be higher than the true values, but it is easier to

avoid errors resulting from the fact that starlings disturbed in nests during inspections desert their clutches.

8. The mean clutch size in the basic period was 4.8 eggs; the values of the means in particular colonies and years varied from 4.5 to 5.5, but these differences were not statistically significant.

9. The clutch size decreased as the breeding period progressed; the clutches in the supplementary period were smaller than in the basic one and the clutches begun in successive parts of the basic period were also smaller and smaller.

10. Young females laid fewer eggs than old ones.

11. The mean number of nestlings hatched in one nest of the basic period in both years was 4.25; in this respect the differences among some colonies were significant.

12. The mean number of fledged young was lower in 1972 (3.4) than in 1971 (3.8) when the mortality of nestlings was higher due to bad weather.

13. In nests of the supplementary period the mean number of hatched nestlings and the number of fledged young were lower than in the basic period.

14. In nests of the basic period the hatching success was 89% in 1971 and 88% in 1972 and the breeding success was 79% and 70%, respectively. For nests of the supplementary period the values were 88% and 84%, and 69% and 64%. The percentage of clutches of the supplementary period in the total production of the young was 6.5% on average.

ACKNOWLEDGEMENTS

I would like to thank Messrs Bolesław Galer and Waldemar Pągowski for their help in collecting and analysing the data. I am grateful to Mrs. Teresa Klim and Messrs Roman Klim, Józef Kurowski and Antoni Zdrojewski for their help in erecting nest boxes. I owe a special debt to all the people who have allowed us to erect nest boxes on their private land or in areas under their control. I acknowledge the help of my colleagues who have read the typescript and expressed their opinions on it. I am particularly grateful to Dr. Wojciech Kania whose remarks have helped me to amend the study. Mrs. Fiona Davies is thanked for linguistic criticism of the English manuscript.

REFERENCES

Anderson, A. 1961. The breeding of the Starling in Aberdeenshire. Scott. Nat. **70**: 60–74.

Augustowski, B. (ed.). 1976. Żuławy Wiślane. Gdańsk, 662 pp.

Berthold, P. 1964. Ueber den Fortpflanzungszyklus suedwestdeutscher Stare (*Sturnus*

vulgaris L.) und ueber bedingende Faktoren der Brutreife beim Star. Die Vogelwarte **22**: 236–275.

BERTHOLD, P. 1966. Zum Verhalten nichtbruetender einjaehriger Stare (*Sturnus vulgaris*). Vogelwarte **23**: 231–232.

BERTHOLD, P. 1969. Ueber Populationsuntersuchung im Gonadenzyklus europaeischer *Sturnus vulgaris, Fringilla coelebs, Erithacus rubecula* und *Phylloscopus collybita* und deren Ursachen. Zool. Jb. Syst. **96**: 491–557.

BOGUCKI, Z. 1972. Studies on the Activity of Starlings *Sturnus vulgaris* LINNAEUS, 1758, in the Breeding Season. Acta zool. cracov. **17**: 97–122.

BOHNSACK, B. 1967. Ein Beitrag zur Lebensgeschichte des Stars, *Sturnus vulgaris*, nach Beobachtungen und Beringungsergebnissen an einer westholsteinischer Population. Corax **2**: 18–26.

BRANDT, S. 1974. Metody statystyczne i obliczeniowe analizy danych. Warszawa, 279 pp.

BUB, H. 1974. Vogelfang und Vogelberingung zur Brutzeit. Wittenberg Lutherstadt, 112 pp.

BUJALSKA, G. 1971. Selfregulation of reproduction in an island population of *Clethrionomys glareolus* (SCHREBER, 1780). Ann. Zool. Fenn. **8**: 91–93.

CAVE, A. J. 1968. The breeding of the Kestrel, *Falco tinnunculus* L., in the reclaimed area Oostelijk Flevoland. Netherlands Journal of Zoology **18**: 313–407.

COLLINS, V. B., DE VOS, A. 1966. A nesting study of the Starling near Guelph, Ontario. Auk **83**: 623–636.

CREUTZ, G. 1939. Biologische Beringungsergebnisse bei Staren, *Sturnus v. vulgaris* L. Mitt. Ver. sächs. Orn. **6**: 18–26.

DARLING, F. F. 1938. Bird flocks and the breeding cycle. Cambridge, 124 pp.

DECKERT, G. 1970. Nestbautechnik, Jungenaufzucht und postnatale Entwicklung beim Star (*Sturnus vulgaris* L.) Beitr. Vogelk. **16**: 50–58.

DELVINGT, W. 1962. L'Etourneau en Belgique: longevite, pontes. Gerfaut **52**: 586–601.

FRASE, R. 1938. Ergebnisse der Beringung grenzmaerkischer Stare. Abh. Ber. grenzmaerk. Ges. nat. wiss. Abt. **12**: 5–36.

GRIFFITHS, J. 1968. Multi-modal frequency distribution in bird populations. Bird Study **15**: 29–32.

GROMADZKI, M. 1978. Abundance of the Starling, *Sturnus vulgaris*, in the breeding season in the vicinity of Gdańsk. Acta orn. **16**: 325–334.

V. HAARTMANN, L. 1966. The nesting habits of Finnish birds. I. Passeriformes. Comm. Biologicae **32**: 1–187.

V. HAARTMANN, L. 1971. Population dynamics. In: D. S. FARNER, J. R. KING (eds.). Avian Biology, vol. 1: 391–459. New York, London.

HARDING, J. P. 1949. The use of probability paper for the graphical analysis of polymodal frequency distributions. J. Mar. Biol. Ass. U. K. **28**: 141–153.

HAVLIN, J., FOLK, C. 1961. Doba hnizdeni a pocet mladat spacku obecnych v CSSR. Zool. Listy **10**: 67–84.

IMMELMANN, K. 1971. Ecological Aspects of Periodic Reproduction. In: D. S. FARNER, J. R. KING (eds.). Avian Biology, vol. 1: 342–391. New York, London.

JOHNSON, S. R., MCTAGGART, C. J. 1974. Thermal adaptations as a factor affecting colonizing success of introduced *Sturnidae* (*Aves*) in North America. Can. J. Zool. **52**: 1559–1576.

KARPOVIČ, V. N. 1962. Ekologija massovych obitatelej iskusstvennych gnezdovij (skvorca, muchołovki-pestruski) v rajone Okskogo zapovednika. Trudy Okskogo Gos. Zap. **4**: 65–176.

KESSEL, B. 1951. Criteria for sexing and ageing european Starlings (*Sturnus vulgaris*). Bird-Banding **22**: 16–23.

KESSEL, B. 1957. A study of the breeding biology of the European Starling (*Sturnus vulgaris* L.) in North America. Amer. Midl. Natural. **58**: 257–331.

KLOMP, H. 1970. The determination of clutch-size in birds. A Review. Ardea **58**: 1–124.
KLUIJVER, H. N. 1933. Contribution to the biology and the ecology of the starling (*Sturnus vulgaris vulgaris* L.) during its reproductive period. Verslagen en Mededeelingen van den Plantenziektenkundigen dienst te Wageningen **69**: 1–145.
KLUIJVER, H. N. 1935. Waarnemingen over de levenswijze van de spreeuw (*Sturnus vulgaris* L.). Ardea **24**: 133–166.
LACK, D. 1948. Natural selection and family size in the Starling. Evolution **2**: 95–110.
LACK, D. 1966. Population studies of birds. London, 341 pp.
LLOYD, J. 1965. Seasonal development of the incubation patch in the Starling. Condor **67**: 67–72.
LUNIAK, M. 1977. Liczebność i produktywność lęgów szpaka — *Sturnus vulgaris* L., w Warszawie. Acta orn. **16**: 241–274.
MONIAK, J. (ed.). 1974. Studium geograficzno-przyrodnicze i ekonomiczne województwa gdańskiego. Gdańsk, 498 pp.
OKTABA, W. 1974. Elementy statystyki matematycznej i metodyka doświadczalnictwa. Warszawa, 310 pp.
PATTERSON, I. J. 1965. Timing and spacing of broods in the Blackheaded Gull (*Larus ridibundus*). Ibis **107**: 433–459.
PIKULA, J., FOLK, C. 1970. Differential breeding in *Corvus monedula*, *Sturnus vulgaris*, *Parus major* and *Fringilla coelebs* in Woodland and non-woodlands habitats. Zool. Listy **19**: 261–273.
PLATT, C. 1974. Problemy rachunku prawdopodobieństwa i statystyki matematycznej. Warszawa, 381 pp.
POLIVANOV, V. M. 1957. Sezonnoe razmeščenie i nekotorye čerty biologii skvorca (*Sturnus vulgaris* L.) po dannym kolcevanija. Trudy Bjuro Kol'c. **9**: 215–241.
RISSER, A. C. Jr. 1975. Experimental modification of reproductive performance by density in captive Starlings. Condor **77**: 125–132.
ROBERTSON, R. J. 1973. Optimal niche space of the Redwinged Blackbird: spatial and temporal patterns of nesting activity and success. Ecology **54**: 1085–1093.
RYDER, J. P. 1972. Biology of nestling Ross's Geese. Ardea **60**: 185–215.
SCHNEIDER, W. 1972. Der Star. Wittenberg Lutherstadt, 127 pp.
TAYLOR, B. J. R. 1965. The analysis of polymodal frequency distributions. J. Anim. Ecol. **34**: 445–452.
TENOVUO, R., LEMMETYINEN, R. 1970. On the breeding ecology of the Starling *Sturnus vulgaris* in the archipelago of south-western Finland. Ornis Fenn. **47**: 159–166.
TROJAN, P. 1975. Ekologia ogólna. Warszawa, 419 pp.
VERHEYEN, R. F. 1969. Arrival at the breeding area, maturity for breeding and onset of laying according to age in the Starling population (*Sturnus v. vulgaris* L.) of lower and middle Belgium. Gerfaut **59**: 378–384.
VERHEYEN, R. F. 1969a. Le choix du nichoir chez l'Etourneau *Sturnus v. vulgaris* L. Le Gerfaut **59**: 239–259.
WAGNER, F. H., BESADNY, C. D., KABAT, C. 1965. Population ecology and management of Wisconsin Pheasants. Wiss. Conserv. Dep. Techn. Bull. **34**: 1–168.
WALLRAFF, H. G. 1953. Beobachtungen zur Brutbiologie des Stares (*Sturnus v. vulgaris* L.) in Nürnberg. J. Orn. **94**: 36–67.
ZAJĄC, R. 1976. Zastosowanie siatek prawdopodobieństwa w badaniach biologicznych. Wyd. Instytutu Sadownictwa, Skierniewice, 12 pp.
ZIELIŃSKI, R. 1972. Tablice statystyczne. Warszawa, 391 pp.
ZINK, G. 1973. Dictionary of ringing and recovery terms. Auspicium **5**, Supplementum: 61–95.

STRESZCZENIE

[Rozród szpaka *Sturnus vulgaris* na Żuławach Wiślanych]

Badaniami objęto blisko dwa tysiące zniesień (Tab. 2) samic gnieżdżących się w skrzynkach lęgowych na Żuławach Wiślanych i w ich sąsiedztwie (Mapa 1, Tab. 1). Stopień wykorzystania skrzynek zależał od gęstości ich rozmieszczenia. Był on wyższy i niezależny od rodzaju siedliska w przypadku skrzynek wiszących oddzielnie lub w małych grupach, niższy zaś i zależny od rodzaju siedliska w przypadku skrzynek gęsto rozwieszonych (Tab. 4). Stopień wykorzystania skrzynek był najwyższy w 1. i 2. roku istnienia kolonii, następnie stopniowo opadał, z wyjątkiem kolonii Lendowo (Tab. 5). W większości przypadków przyczyny tego spadku pozostały nieznane, choć jedną z nich mogło być drapieżnictwo (kuny, wiewiórki).

Chwytanie samic w skrzynkach (Tab. 3) wykazało, że do rozrodu przystępują także samice młode — w 2. kalendarzowym roku życia. Ich udział był szczególnie wysoki w pierwszym roku istnienia kolonii (66 %), malejąc w latach następnych do 30 % (Tab. 6). Liczba młodych samic była wysoka także w koloniach, w których drapieżniki zniszczyły znaczną liczbę samic starych, nie zależała natomiast od liczby wolnych skrzynek lęgowych.

Badana populacja ma jeden lęg w roku. Synchroniczność składania jaj przez poszczególne samice jest bardzo duża. Czas składania jaj podzielono na dwa okresy: podstawowy i dodatkowy (Rys. 1 i 2). Okres podstawowy trwał krótko, lecz w jego trakcie znoszone było 80 % jaj. W czasie okresu dodatkowego składane były jaja ze zniesień opóźnionych i powtarzanych. Te ostatnie stanowiły około 4,5 % jaj znoszonych w danym roku, co określono na podstawie analizy kształtu krzywej (kumulanty) dat znoszenia jaj, narysowanej na siatce prawdopodobieństwa dla rozkładu normalnego (Rys. 3 i 4). Samice młode składały jaja średnio o 1,5 dnia później niż stare (Tab. 7).

W okresie podstawowym pełne zniesienia składały się średnio z 4,8 jaj (Tab. 8 i 9). Wielkość zniesień okresu dodatkowego była mniejsza. Zmniejszała się ona także w kolejnych podokresach okresu podstawowego (Tab. 11 i 12). Młode samice składały mniej jaj niż stare (Tab. 13).

Średnie liczby piskląt, wykluwających się w jednym gnieździe i wylatujących z jednego gniazda, obliczono biorąc pod uwagę tylko te zniesienia, w których wykluło się przynajmniej jedno pisklę. Tak uzyskane wartości są wprawdzie zawyżone, ale umożliwiają porównanie różnych kolonii, gdyż nie są obciążone stratami, powstałymi w wyniku płoszenia wysiadujących samic w trakcie kontrolowania skrzynek. Straty te mogą być znaczne i zależą od sposobu dokonywania kontroli oraz od warunków miejscowych.

W okresie podstawowym średnia liczba wykluwających się w jednym gnieździe piskląt wynosiła 4,25 (Tab. 14 i 15), średnia liczba młodych opuszczających gniazdo — 3,8 w 1971 r. i 3,4 w 1972 r. (Tab. 17 i 18). Duża śmiertelność piskląt w roku 1972 spowodowana była złą pogodą. W okresie dodatkowym liczby wykluwających się i opuszczających gniazdo piskląt były niższe.

Redaktor pracy — dr Wojciech Kania

Państwowe Wydawnictwo Naukowe — Warszawa 1980
Nakład 870+90 egz. Ark. wyd. 2,75; druk. 2. Papier druk. sat. kl. III, 80 g. B1. Cena zł 20,—
Zam. 992/79 — Wrocławska Drukarnia Naukowa

ISBN 83-01-01058-4
ISSN 0001-6454