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NEST BUILDING DYNAMICS OF A BREEDING COLONY OF ROOK (*CORVUS FRUGILEGUS* L.)*

This paper reports six years of observations on nest building in a town breeding colony of rooks. General lines in the development of the colony of rook during the breeding season have been considered and particular stages of the nest building process have been analysed. Main point is the influence of weather conditions upon nest-building.

Many ornithologists (Baker 1938, Marshall 1949, Lack 1950, Thomson 1950, Belopolsky 1956) dealt with the breeding time determination in birds. These authors were mainly interested in the effect of various ecological factors determining the breeding time of a given species. Baker (1938) divided these factors into two main groups: ultimate factors and proximate factors. An ultimate factors is, according to Baker, the possibility of having maximum food supply throughout the period of feeding the young. Lack (1950) and Thomson (1950) did agree with this opinion and gave a lot of persuasive examples. Precise determination of breeding time is, according to these authors, a consequence of evolutionary adaptation which arised by means of natural selection. As proximate factors these authors considered those stimulating the growth and activity of gonads, i.e. mainly temperature (also Marshall 1949 and Owen 1959), day length and available food supply. Belopolsky (1956) in his work concerning chiefly *Laridae* of the far North, pointed out that for these birds the only factor influencing the breeding time was the amount

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of accesible food and he decidedly neglected any influence of temperature and day length.

While the above mentioned problems are widely discussed, there is an evident need for detailed field research on the direct influence of environmental conditions on the activity of birds which begin to build their nests. The paper by Pitt (1929) dealt with this subject only superficially. In the papers by Marshall and Coombs (1957) and Owen (1959) only the influence of temperature on the beginning of nest building activity and on the time of egg laying was taken into consideration.

Such studies can be made on various material. One can observe in detail the behaviour of particular bird couples breeding individually. This method however would be, extremely time-consuming and the results obtained hardly comparable. One can also observe birds breeding colonially. In this case the results come from summing up of all the particular individual phenomena and, if the colony is sufficiently numerous, are reliable and can be considered as an average reaction of a given bird species to given environmental conditions. However, it must be always kept in mind that a colony is not only a sum of individuals, but, being a definite social unit, it does influence the behaviour of individual couples. The often observed "epidemics" of stealing material from neighbouring nestes, may serve as a good example of such influence. These "epidemics" result in destruction of nests which would not happen among birds breeding individually. Those peculiarities of social life warn us to be cautious in generalizing the results and extending conclusions to other species, especially individually breeding ones. This paper considers the "proximate factors" as determining the time when the building of a colony starts.

Besides this, the effect of these factors on further stages of colony development and nest building is discussed. In addition the analysis of succesive stages of nest building is given. The paper aims at describing the regularities in nest building behaviour of rooks and duration of successive stages of this process as well as the influence of weather conditions on these processes.

DESCRIPTION OF COLONY

The observed colony is situated in three rows of high poplars growing along the Rakowiecka street in Warsaw, two rows on one side of the street, one row on the other. At its south and east sides the colony is surrounded by the close-set town buildings (Fig. 1). To the north, in the proximity of the colony, there are the buildings of the Warsaw Agricultural University and farther north a park and open Mokotów Field which is a vast area of grass, weed and clumped trees. West and south-west there are the gardens of Jesuit Cloister, garden allotments and municipal nursery gardens. The role of all these territories in the life of the rook colony has already been discussed in earlier papers (Busse 1961, 1962). Gaps in the tree-rows divide the colony into

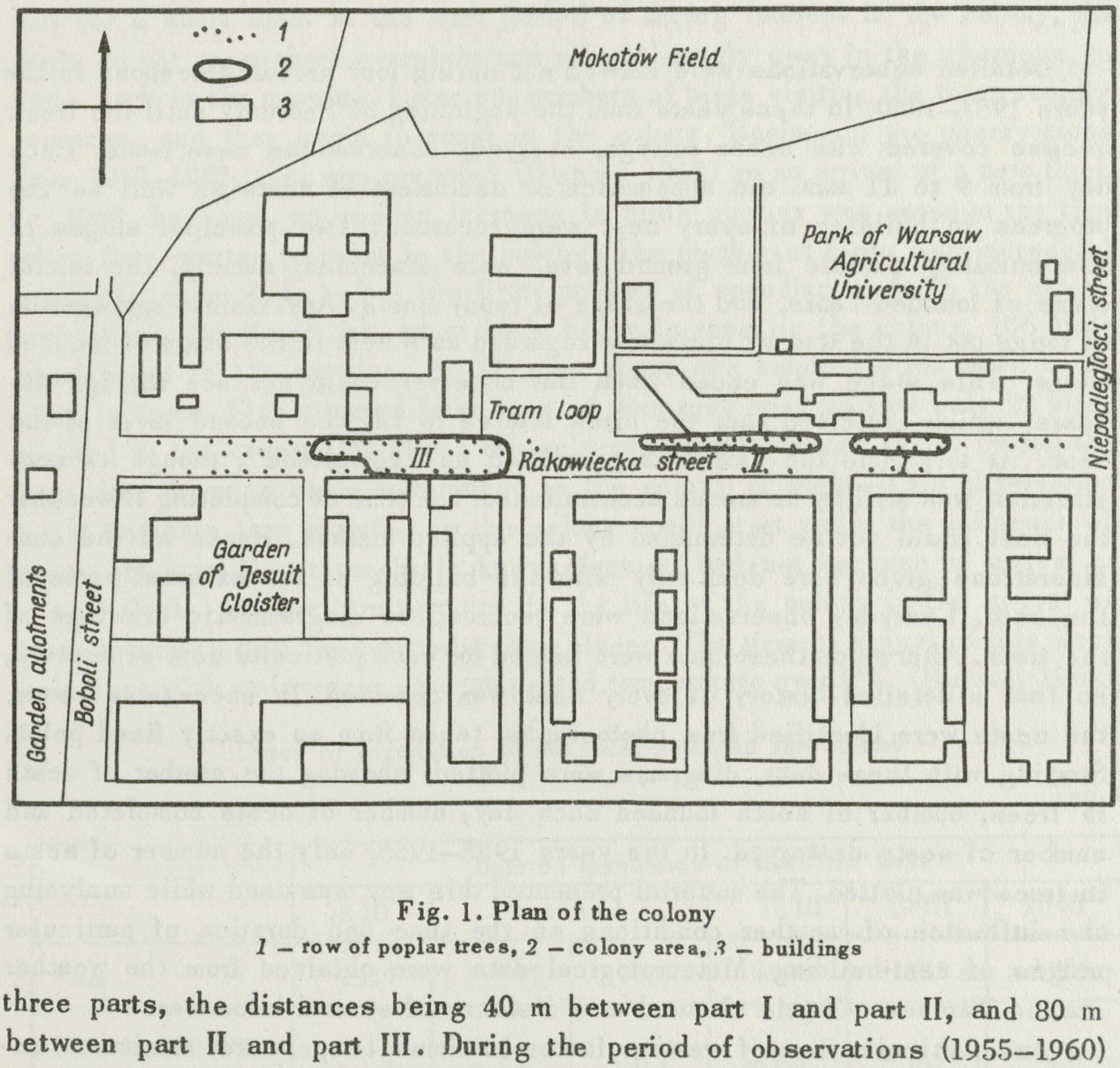

Fig. 1. Plan of the colony
1 – row of poplar trees, *2* – colony area, *3* – buildings

three parts, the distances being 40 m between part I and part II, and 80 m between part II and part III. During the period of observations (1955–1960) nests were noted in 52 trees out of a total of 73 trees growing there. In parts I and II rooks occupied only trees of the two north-side rows close to each other which were situated farther from the buildings. In the third row, here and there broken, nearest to the buildings, no trees were inhabited by rooks. In part III, during the years 1955–1958, in trees of this single row, nests were rather numerous. In 1958, these nests were thrown down and all the branches in which they had been located were broken. Since that, despite some attempts, birds did not breed there. The number of nests in the colony fluctuated from 123 (1956) to 75 (1960) showing a general decreasing tendency.

METHODS

Detailed observations were carried out during four breeding seasons in the years 1957–1960. In these years from the beginning of February until the trees became covered with dense foliage, everyday observations were made. Each day from 9 to 11 a.m. the appearance or decrement of nests as well as the progress in building of every nest were recorded. Two principal stages of nest-building, visible from ground level were discerned, namely, the initial stage of founded basis, and the stage of ready basis. Any visible aggregation of twigs put in the tree by birds was regarded as a nest in the stage of founded basis. This stage was ended when the observer could not see through the basis, which indicated that the birds started to lay the second layer of the nest. At this time the nest was classified as "completed", though its construction was still by no means accomplished. The time of completing thoroughly the nest could not be determined by the applied method. Hence all the considerations given here deal only with the building of the external parts of the nest. Everyday observations were recorded on diagrammatic drawings of the trees. Afterwards these data were tallied for each particular nest separately, so that a detailed history of every nest was obtained. In successive years, the nests were identified from photographs, taken from an exactly fixed point. Starting with these data, diagrams were plotted, showing the number of nests in trees, number of nests founded each day, number of nests completed and number of nests destroyed. In the years 1955–1956, only the number of nests in trees was plotted. The material presented this way was used while analysing the influence of weather conditions on the time and duration of particular stages of nest-building. Meteorological data were obtained from the weather station Warszawa-Okęcie situated at a distance of several kilometers.

Any particular item of weather factor (minimum temperature, maximum temperature, mean temperature, rapidity of temperature changes, rapidity of pressure changes, windiness, cloudiness) was estimated by choosing days in which the concerned factor showed the same or similar values. Subsequently, mean numbers of nests founded or destroyed per day were calculated. All such calculations were done for each period of colony development separately, but for the years 1957–1960 jointly, and they were compared, when it was possible, with similarly obtained data for the years 1955–1956.

The nest-building stages were analyzed for every year separately, and then totalled for the whole period of study.

The results which recurred every year were considered as reliable ones.

RESULTS

GENERAL OUTLINE OF THE COLONY FORMATION

Rooks appearing regularly in trees of the breeding colony were observed from about mid February (Busse 1962). At this time the birds come in small numbers and for a short time. In the first period of taking interest in the colony, the birds do not roost there overnight and all of them fly away in the afternoon, to come back in the morning. Later on, numbers of birds visiting the trees rapidly increase, and they begin to roost in the colony. Basing on the observations from 1955–1957, this was regarded (Busse 1962) as an arrival of a new flock. In 1960, however, no sudden increase in birds' number was noted at the time when they started to roost in the colony. The number of birds was increasing gradually some days before the first incident of spending night in the colony took place. On March 5th, when birds began to roost in the colony, 106 birds were noted in the morning. At 5^{45} p.m. about one hundred birds were to be seen in trees. Five minutes later most of then took wing so that only 22 birds roosted in the colony. On March 6th only one couple roosted there. During the next four days no birds were found in the colony at night. This observation might indicate that roosting in the colony could start under the influence of some other, still not precisely known factors, and not because of arrival of a new flock. Another turning point in the life of the colony is the arrival of birds returning from far-away wintering places. The time of arrival of this flock coincides with an increase of mean pentad temperature over 0°C (Busse 1962).

Dates of foundation of the first nests in the colony

Tab. I

	Date of foundation of the first nest					
	8 III	13 III		16 III	19 III	20 III
Year	1959	1957	1960	1958	1955	1956
Mean temperature in centigrades	+ 1.2	+ 1.0	+ 0.1	− 1.8	− 6.1	− 8.6
Mean temperature in centigrades (1–14 II)	− 4.8	+ 4.6	− 6.5	+ 1.6	+ 1.7	−15.4

Birds which wintered nearby the colony start to be busy with nests even before they begin to roost in the colony, so that the first nests are built before the migrant rooks arrive. This when the first nest appears in the colony depends upon temperature conditions throughout the second half of February (Tab. I).

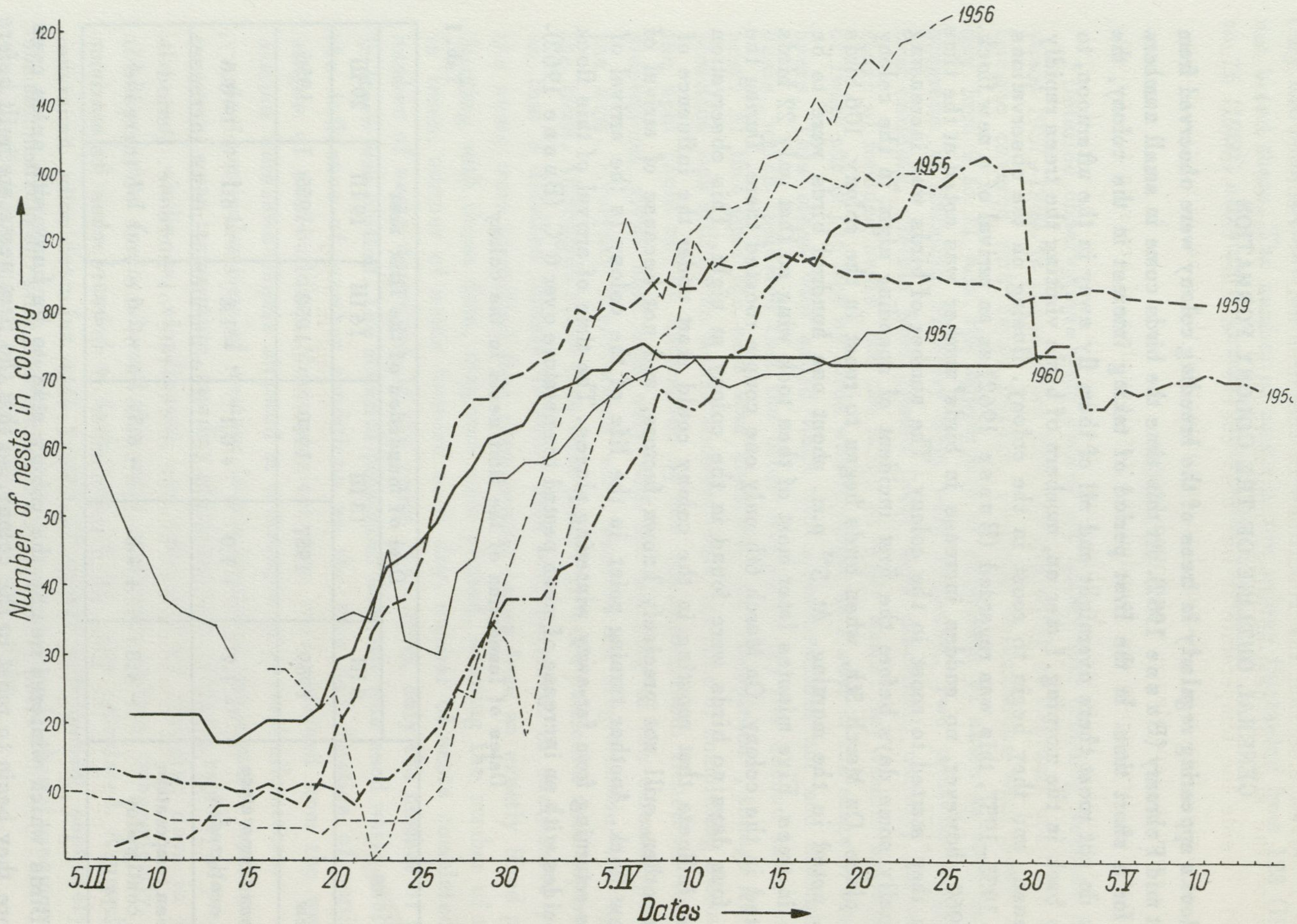

Fig. 2. Colony development

Table I proves also that the conditions in the first half of February do not influence the start of nest-building. Similar results were obtained by Owen (1959). Beside the temperature it was also checked whether the synoptic patterns occurring from mid February had any effect on the start of nest-building. But no such a dependence was found.

When the first nests are founded the total number of nests in the colony does not usually increase. At this time the building activity is still lower that the activity manifested by fighting in nests and destruction of old nests. Moreover, not all the birds lay down their nests simultaneously (Ogilvie 1951, Coomps 1960, Nau 1960). The changes in number of nests from year to year are shown in Figure 2. Already at first sight it is clear that the curves show an essential similarity – all of them are an approximation of a sigmoidal curve[1]. It is not intended here to produce equation of this curve, but simply to use it to divide the time of colony formation into several periods. This was done as follows (Fig. 3). Period I lasts from the foundation of the first nest

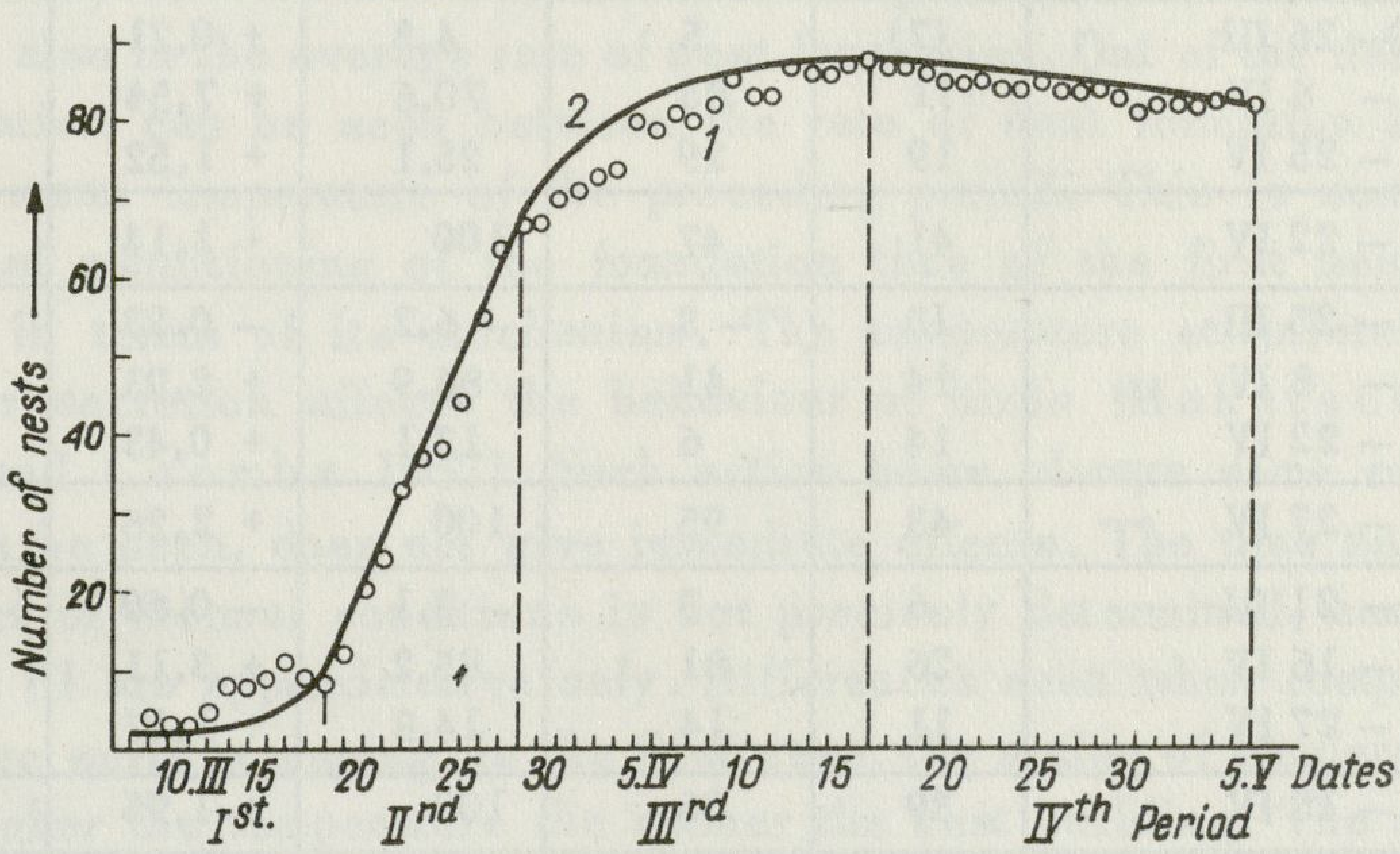

Fig. 3. Diagram of colony development in 1959
1 – values observed, 2 – fitted curve

to the moment of rapid increase in nest number. It is a period of preliminary, slow progress of colony formation. In period II the number of nests increases very rapidly without conspicuous changes in the rate of increase. Period III lasts from the moment of a sudden slowing down of the rate of increase in numbers of nests to the time when the number of nests reaches its maximum for a given year. The rate of the colony development gradually diminishes during this period. Period IV comprises the time following the maximum number of nests. At this period a slow, constant decrease in the number of nests is observed which implies that some of the birds which have built nests do not

[1] Rapid decreases in 1955 and 1958 were caused by the destruction of nests.

Characteristics of the succesive periods of the colony development

Tab. II

Year and period	Duration of period		Changes in total number of nests*		Changes in total number of nests per day	Maximum number of nests observed
	dates	number of days	number of nests	%		
1955	(19 III)– 17 IV	(30)	100	100	+ 3.33	100
I	(19 III)– 22 III	(4)	2	2	+ 0.50	
II	23 III – 10 IV	19	90	90	+ 4.74	
III	11 IV – 17 IV	7	10	10	+ 1.43	
1956	(20 III)– 25 IV	(37)	117	100	+ 3.17	123
I	(20 III)– 26 III	(7)	5	4.3	+ 0.71	
II	27 III – 6 IV	11	83	70.6	+ 7.54	
III	7 IV – 25 IV	19	29	25.1	+ 1.52	
1957	13 III – 22 IV	41	47	100	+ 1.14	78
I	13 III – 25 III	13	– 3	– 6.2	– 0.23	
II	26 III – 8 IV	14	41	86.9	+ 2.93	
III	9 IV – 22 IV	14	6	13.1	+ 0.43	
1958	16 III – 27 IV	43	95	100	+ 2.26	103
I	16 III – 21 III	6	– 3	– 3.1	– 0.60	
II	22 III – 16 IV	26	81	85.2	+ 3.11	
III	17 IV – 27 IV	11	14	14.8	+ 1.27	
1959	8 III – 15 IV	39	86	100	+ 1.95	88
I	8 III – 18 III	11	6	7.2	+ 0.55	
II	19 III – 28 III	10	59	68.4	+ 5.90	
III	29 III – 15 IV	18	21	24.4	+ 1.16	
1960	13 III – 7 IV	26	58	100	+ 2.32	75
I	13 III – 19 III	7	5	8.6	+ 0.83	
II	20 III – 30 III	11	40	68.8	+ 3.62	
III	31 III – 7 IV	8	13	22.6	+ 1.62	
1957–1960	8 III – 27 IV	35.2	82.2	100	+ 2.33	98.2
I	8 III – 25 III	7.2	2.0	2.5	+ 0.28	
II	19 III – 16 IV	15.2	65.7	78.9	+ 4.32	
III	29 III – 27 IV	12.9	15.5	18.6	+ 1.20	

* The given values represent the differences between highest and lovest number of nests observed during the period in question percentages are calculated taking this difference for the whole year as 100 per cent.

complete their breeding cycle. The week preceding period I was named the preliminary period. Introducing this term will facilitate further discussion.

Table II shows duration and changes in number of nests for each particular period of the years 1955–1960. Comparing the values given there for subsequent periods two types of arrangement are discernible. One of them is that when a large number of nests (85.2–90% of the total) is founded in period II and a small number (10–15%) in period III. The ratio of period III to period II is 0.11 (1955) to 0.17 (1958). The other one is when this difference is less marked, period II showing foundation of 68.4–70.6% of nests, and period III 22.6–25.1% respectively. The ratio of period III to period II amounts to 0.32 (1960) and 0.35 (1956, 1959). This classification is in accordance with dividing the years into these when during period I the number of nests diminished (1957, 1958) or only slightly increased (1955), and those when period I was favourable. The above ratios reveals one important factor influencing the shape of the obtained curves.

Duration of a particular period as well as that of the whole development of the colony is rather variable in different years. Remarkable differences can be noted also in the average rate of nest foundation. Out of the data in Table III, a correlation can be seen between the rate of nest formation in each period and the mean temperature of the preceding period. This is somewhat similar to thermal conditioning of the foundation time of the first nests; and rather obvious in terms of its mechanism. The temperature stimulate's the gonads, and their secretion affects the behaviour of birds (Makatsch 1957, Marshall and Coombs 1957). Such action bears always some retardation and, as it can be seen, does not give immediate effects. The time needed to reveal the effect of thermal conditions is not precisely determined, hence the values in Table III are approximative only. Differences seen when comparing Tables I and III are worth stressing. In the first case, the action of temperature is simple – the higher the temperature the sooner the nest building. The other case, as can be seen from Table III, is more complicated: the rate of nest building is highest when the temperature of the preceding period is nearest to many-year mean temperature of that period (mean for 1955–1960). This indicates some adaptation to the most typical temperatures for a given period. Data confirming such an explanation will be discussed below. No other weather factors were found to exert any influence on the nest-building rate.

Factors causing remarkable fluctuations in duration of the same periods in different years are still obscure. Probably a very complex group of factors operates here. The above mentioned thermal conditions of the preceding period as well as the present ones have some bearing upon the duration of periods. Also the birds returning from their wintering places arrive at different moments of the colony formation. Thus the migrant rooks arrived on: March 11, 1957; March 14, 1959; March 24, 1956; and March 26, 1955 (author's own observa-

Changes in total number of nests in relation to temperature

Tab. III

period I

	1958	1960	1956	1955	1957	1959	Mean
Duration of period I (days)	5	7	(7)	(4)	13	11	7.2
Mean temperature of period I	-4.3	+4.4	-2.2	-2.4	+3.9	+1.5	+0.1
Mean temperature of preliminary period	-3.7	-2.8	-2.7	-1.9	-0.1	+4.7	-1.1
Difference from mean temperature of preliminary period for the years 1955–1960	-2.6	-1.7	-1.6	-0.8	+1.0	+5.8	–
Changes in total number of nests per day	-0.60	+0.83	+0.71	+0.50	-0.23	+0.55	+0.28

period II

	1958	1955	1956	1959	1957	1960	Mean
Duration of period II	26	19	11	10	14	11	15.2
Mean temperature of period II	+0.9	+3.9	+2.9	+6.9	+8.3	+4.5	+4.5
Mean temperature of period I	-4.3	-2.4	-2.2	+1.5	+3.9	+4.4	+0.1
Difference from mean temperature of period I for the years 1955–1960	-4.4	-2.5	-2.3	+1.4	+3.8	+4.3	–
Changes in total number of nests per day	3.11	4.74	7.54	5.90	2.93	3.63	4.32

Tab. III (con.)

period III

	1958	1956	1955	1960	1959	1957	Mean
Duration of period III	11	19	7	8	18	14	12.9
Mean temperature of period III	+6.7	+5.5	+4.8	+2.6	+6.9	+4.3	+5.1
Mean temperature of period II	+0.9	+2.9	+3.9	+4.5	+6.9	+8.3	+4.5
Difference from mean temperature of period II for years 1955–1960	-3.6	-1.6	-0.6	0.0	+2.4	+3.5	–
Changes in total number of nests per day	1.27	1.52	1.43	1.62	1.16	0.43	1.20

tions). In these years the migrant birds arrived in the course of period I (1956, 1959) and of period II (1955) or on the preceding days (1957). Besides, these birds were migrating under various conditions and arrived having the nest-building instinct variously developed.

Rooks nested in 52 trees out of 73 growing in the study area. The number of nests per tree was very variable and ranged from 1 to 13. The frequencies of different numbers are given in the diagram (Fig. 4). It is remarkable that the number of nests was by no means limited by a small number of suitable branches and that every year some places which were occupied a year ago were left free. It was also found that the birds occupied the safest branches first of all, giving a chance of successful finishing the nest-construction. Out of the nests which were built as the first or the second one in any particular tree, on the

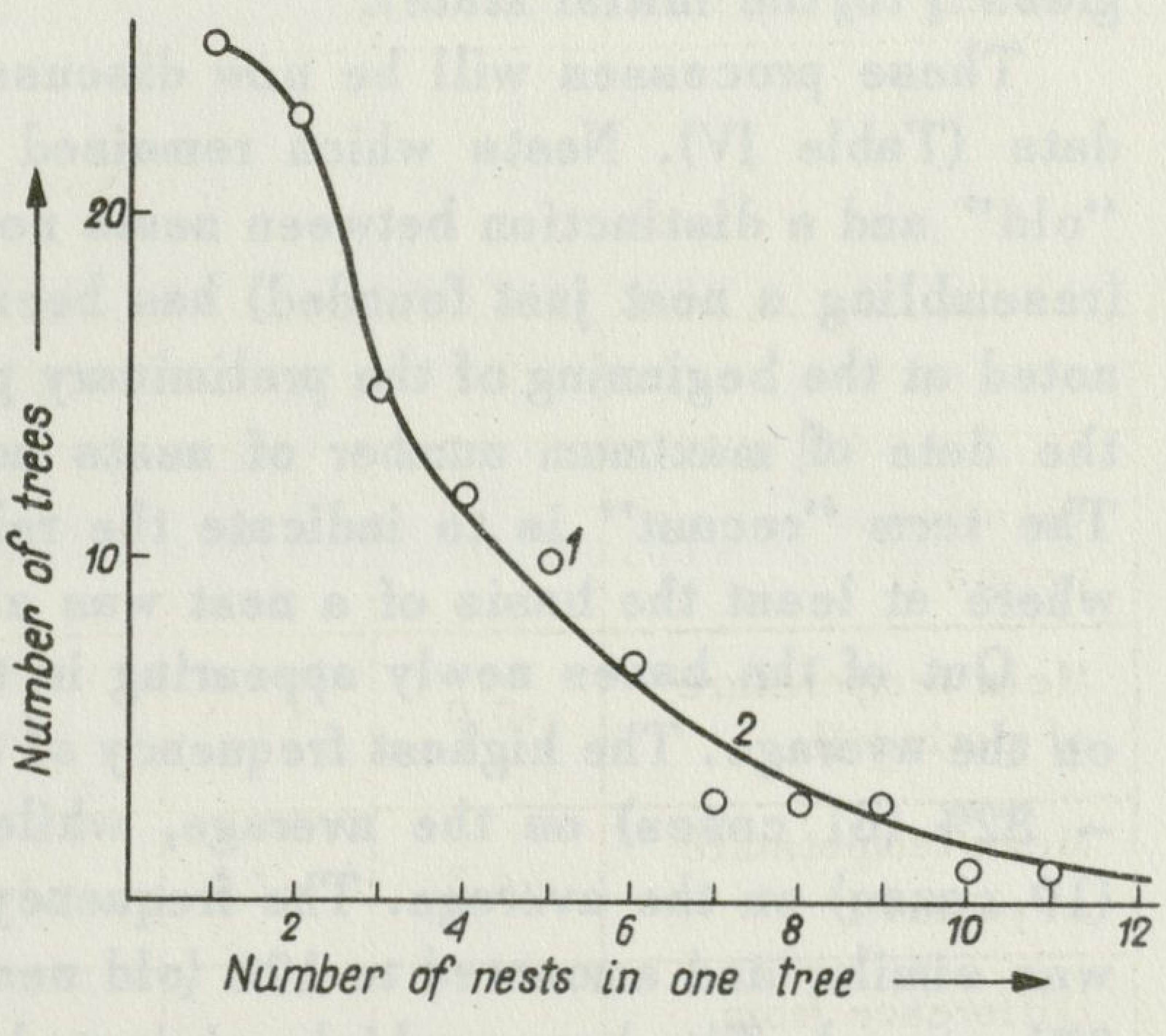

Fig. 4. Number of nests per one tree
1 – values observed, 2 – fitted curve

average 88% lasted till the end of the observations. This percentage gradually decreased for the nests built successively as the third or fourth, fifth or sixth, seventh or eighth. Out of the nests built as ninth and up to thirteenth only 76,5% were left at the end of observation period.

THE NEST-BUILDING PROCESS

A rook nest is built in three stages: first an outer basket is made from small twigs, then the nest is reinforced with finer material mixed with soil and at last the inside is lined finally.

The method applied here enabled to ascertain only two stages of the nest-building process: the foundation of a nest and the start of lining of the finished basket with compact non-transparent material of the second layer. While observing the sequence of these two stages in time, the following variants may be discerned:

1) destruction of the nest basis,

2) remaining of a free place after the nest was destroyed and before the next one was founded in this spot,

3) outer basket completed,

4) thorough destruction of a completed nest or severe damaging of it ("regress" to the initial state).

These processes will be now discussed in detail basing on the collected data (Table IV). Nests which remained from the previous year were termed "old" and a distinction between nests not damaged and those heavily damaged (resembling a nest just founded) has been made. The number of old nests was noted at the beginning of the preliminary period. Two final dates were assumed: the date of maximum number of nests noted and of the end of observations. The term "recast" is to indicate the rebuilding of a nest in the same place where at least the basis of a nest was already founded earlier in this season.

Out of the bases newly appearing in trees 22% (421 cases) were destroyed on the average. The highest frequency of destruction is observed during period I – 82% (61 cases) on the average, while the lowest during period IV – 12% (19 cases) on the average. The frequency of destruction of new and old bases was similar and amounted to 19% (old nests – 50 cases) and 22% (new nests – 371 cases). The bases which originated from partial destruction of completed nests were further destroyed much more often – 79% on the average.

The destruction of new bases usually took place on the next day after they were founded (Fig. 5). On following days the number of destroyed bases quickly decreased, so that among those which withstood four days (from the date of their foundation) no further destruction was observed. Mean time of destroying the newly built bases slightly fluctuated from year to year and amounted from 1.33 to 1.52 days, the average being 1.46 day (76 cases). When in the place of

Basic material for analysis of stages of nest – building

Tab. IV

			1957 Preliminary period started 6 III	1958 Preliminary period started 9 III		1959 Preliminary period started 1 III		1960 Preliminary period started 6 III	
Date of observation			22 IV	27 IV	13 V	15 IV	5 V	7 IV	1 V
Total number of nests observed			126	115	121	102	109	77	80
Total of old nests ⊙+ X			43+15 58	11+1 12	11+1 12	2+2 4	2+2 4	19+6 25	19+6 25
Total of new nests			68	103	109	98	105	52	55
Existing on the day at observation	⊙ + X		20+5 25	7+1 8	4+0 4	2+1 3	2+1 3	18+6 24	18+6 24
	New		61	94	65	86	82	51	49
	No recasting	⊙ + X	10+0 10	3+0 3	1+0 1	0+1 1	0+1 1	12+2 14	12+2 14
		New	41	78	58	71	66	40	42
	Basis founded only		–	4	–	1	2	–	–
	Recast: Total	⊙ + X	10+5 15	4+1 5	3+0 3	2+0 2	2+0 2	6+4 10	6+4 10
		New	18	12	7	11	10	8	7
	Recast: One recast	⊙ + x	7+4 11	3+1 4	3+0 3	2+0 2	2+0 2	4+3 7	4+3 7
		New	14	6	5	8	8	6	6
	Recast: Twice recast	⊙ + x	2+1 3	–	–	–	–	1+0 1	1+0 1
		New	4	–	–	–	–	–	–
	Recast: Regression	⊙ + x	1+0 1	1+0 1	–	–	–	–	–
		New	–	5	2	–	–	1	2
	Recast: Recast with subsequent regression	⊙ + x	–	–	–	–	–	2[4]	2[4]
		New	–	1[1]	–	1[3]	1[3]	–	–
	Regression	New	–	–	–	2	1	2	–
	Origin unknown		2	–	–	3	4	–	–
	Total		86	102	69	89	85	75	73
Destroyed till the day of observation	Not repaired	⊙ + X	19+8 27	4+0 4	3+0 3 2+0[2] 2[2]	0+1 1	0+1 1	1+0 1	+0 1
		⊖ + ✳	2+5 7	3+6 9	4+4 8 26+0[2] 26[2]	4+6 10	15+7 22	–	4+0 4
	Repaired	⊙ + X	4+2 6	–	– – 2+1[2] 3[2]	–	–	–	–
		⊖ + ✳	–	–	2+2 4 3+1[2] 4[2]	1+0 1	1+0 1	0+1 1	0+2 2
	Regression	⊙ + x	–	–	–	–	–	–	–
		⊖ + ✳	–	–	1+0 1 2+0[2] 2[2]	1+0 1	0+1 1	–	–
		⊙ + X	23+10 33	4+0 4	3+0 3 4+1[2] 5[2]	0+1 1	0+1 1	1+0 1	1+0 1
		⊖ + ✳	2+5 7	3+6 9	7+6 13 31+1[2] 32[2]	12	23	1	6
	Total		40	13	16 36[2]	13	24	2	7

[1] Once recast with subsequent. [2] Destroyed by men. [3] Four times recast. [4] Once recast and twice recast with subsequent regression.

⊙ – old nest, not damaged at the begining of preliminary period,
X – old nests, damaged at the begining of preliminary period,
⊖ – completed basis destroyed,
✳ – just founded basis destroyed.

a destroyed basis a new nest was founded, such a destruction was called "incomplete destruction". On the other hand when in a given year no rebuilding was observed, such destruction was called "complete destruction". The frequency of these two types of destruction was different in different periods (Tab.V). The number of incomplete destructions decreases from I to III period, while that of the complete ones is highest in period II. The increase in number of incomplete destructions might be explained when assuming that fully matured birds after the destruction of a just founded basis, continued as a rule, the rebuilding at the same spot. In period I the majority of birds collected their material by breaking off twigs from neighbouring trees and were particularly inclined to steal material from other nests. Frequently occurring fights between owners and intruders usually ended in a destruction of nest basis. In period III the number of mature birds which still have no nests of their own was low and hence fights destroying nests were more rare. The incidence of complete destructions occurring mainly at the time the highest rate of increase in number of nests implied that in the studied colony, similarly as it was observed by Owen (1959), not fully matured birds also start building nests. They may do so, simply following matured specimens. But, due to a low development of building instinct these birds did not repair the basis, once it was destroyed, which results in "complete destruction".

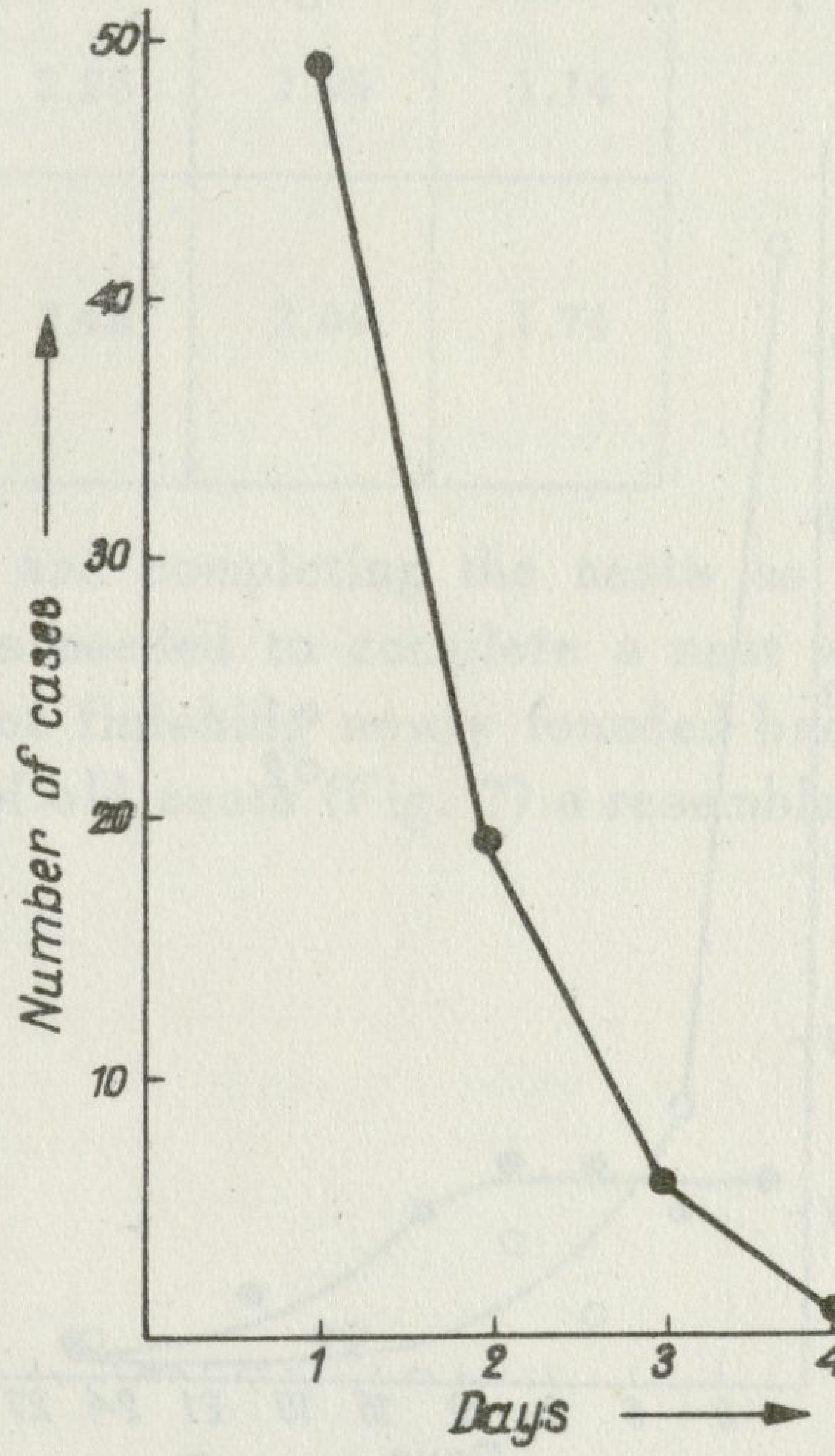

Fig. 5. Time needed to destroy a basis

Mean number of nests destroyed per day

Tab. V

	Period		
	I	II	III
Complete destruction	0.05	0.12	0.06
Incomplete destruction	0.49	0.29	0.12

The time needed to destroy completely a basis arisen by damaging a ready nest (regression) was longer (up to 14 days), 2.99 days on the average. Here also the destruction during one day was most common.

The interval between destruction and rebuilding was entirely different history they went through in the season (Fig. 6). For "old" nests the average was 11.00 days (36 cases) and for "new" nests, destroyed for the first time – 4.20 days (49 cases). Different shape of curves (Fig. 6) was probably due to different psychical condition of birds having new or old nests. In birds which have occupied a ready, or only slightly damaged old nest the nest-building instinct was developed poorly, since the possession of a nest inhibited this instinct. These individuals which occupied the nests damaged to a different degree had the building instinct developed to a different degree respectively, so that the rebuilding started with a smaller or bigger delay (the long horizontal line in the diagram). On the other hand, those birds which founded their nests for the first time, their building instinct being in full swing reacted to the loss of the nest in stereotypic way, i.e. by soonest rebuilding of the nest. Individual variability caused that not all specimens reacted exactly in the same way which resulted in a diagram resembling one branch of the logistic curve.

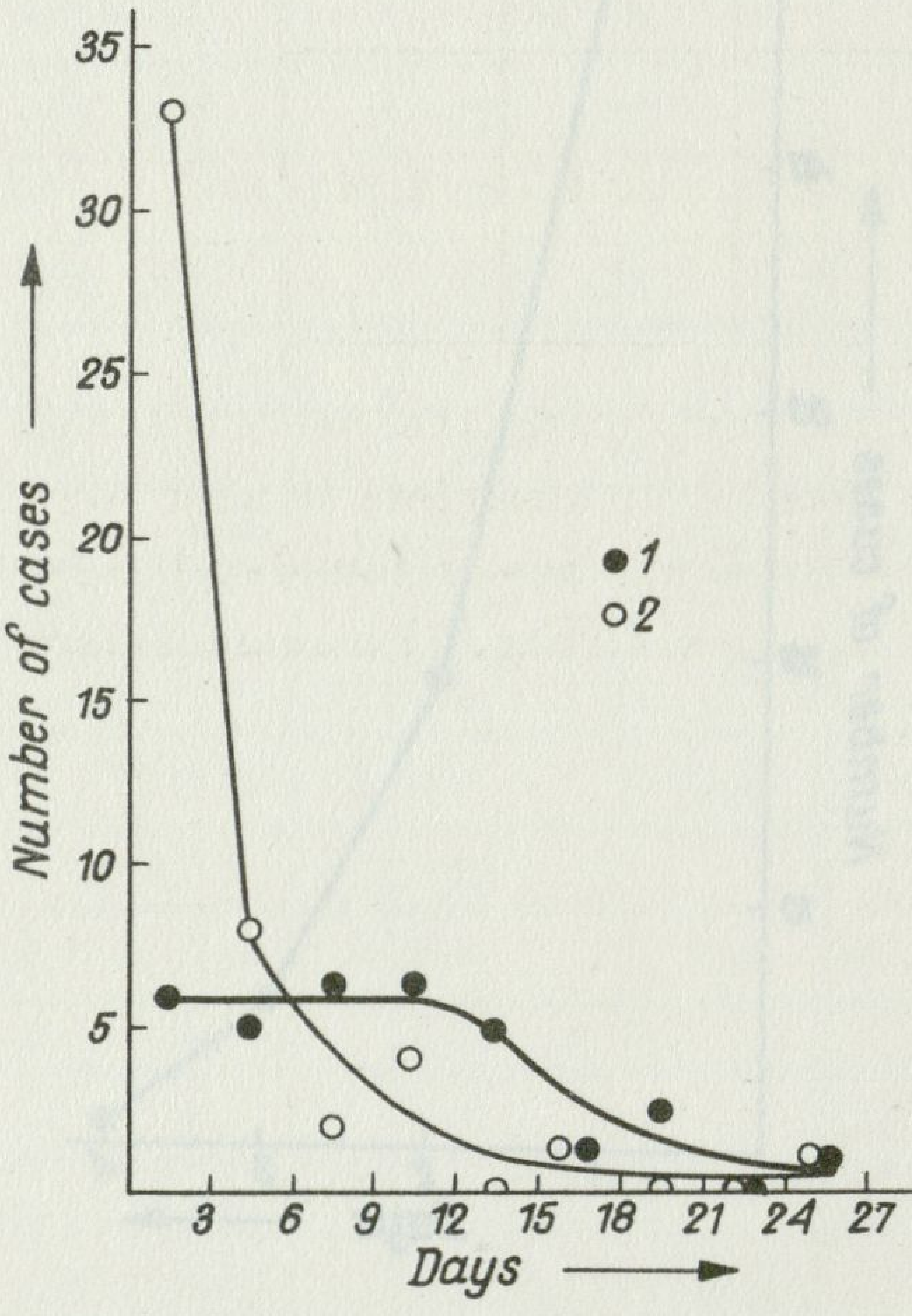

Fig. 6. Delay between destruction and rebuilding of nests
1 – old nests, 2 – new nests

As it was already said, the construction of the majority of newly founded bases proceeded and was accomplished. Most typical pattern was to complete the nest in one or two days since the basis was founded. The rate of completing the founded bases was different in different years. Thus in 1957 and 1959 the this process lasted mostly one day, while in 1958 and 1960 it took two days. Mean time needed to complete a nest varies from 1.74 days to 2.49 days, the average being 2.29 days (339 cases). It is remarkable that the average time of completing a nest is proportional to the rate of founding new nests (Table VI). This is hard to understand, as it seems that both these processes result from the same kind of activity. Still, the weather conditions analysis speaks in

Rate of founding and completing the bases

Tab. VI

	Year			
	1960	1958	1959	1957
Mean number of bases founded per day	2.32	2.26	1.95	1.14
Mean time needed to complete a basis (days from foundation to completing)	2.49	2.48	2.04	1.74

favor of regarding the foundation of bases and completing the nests as two different things. The longest observed times needed to complete a nest were 10 and 14 days. While comparing the rate of finishing newly founded bases, recast ones and of those built in the place of old nests (Fig. 7) a resemblance

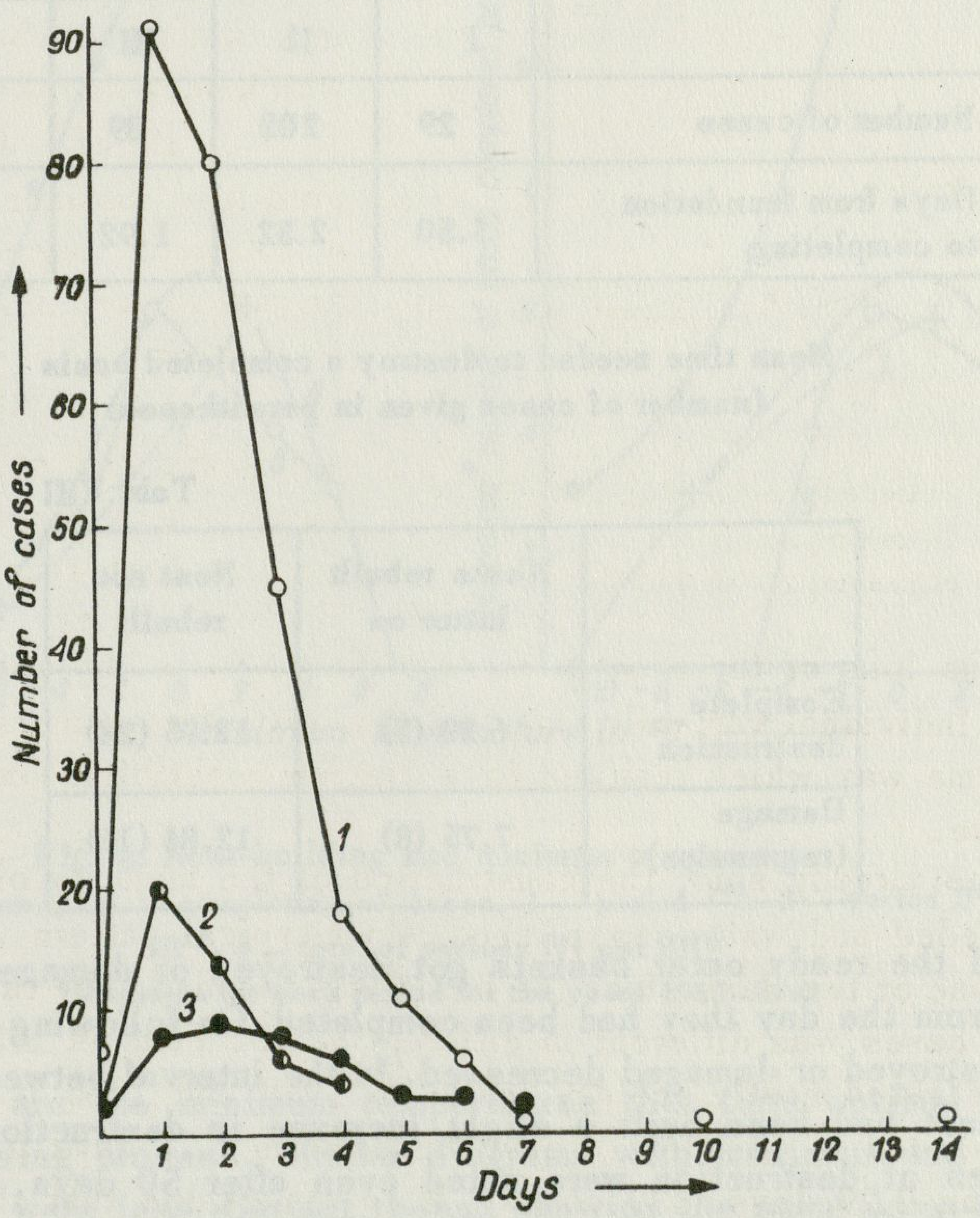

Fig. 7. Time needed to complete a basis (days from foundation completing)

1 — new nests, *2* — recast nests, *3* — old nests of the two groups first mentioned is visible. Diagrams for both these groups show a distinct maximum peak and in the further course they are similar to each other. Diagram depicting the rate of finishing "old" nests is more flattened and does not show any pronounced maximum. The average time needed to finish an "old" nest was longer (2.88 days – 42 cases) than that of "new" (2.09 days – 261 cases) and of "recast" ones (1.95 days – 46 cases). Time needed to complete a basis made by "regression" had intermediate values – 2.40 days (10 cases). These data confirm the above expressed opinion as to the differences between birds posessing "new" and "old" nests. The rate of finishing the nests was growing during the whole colony development (Tab. VII), i.e. birds founding their nest late is season completed it relatively faster than birds which started their nest earlier.

Mean time needed to complete a basis in different periods

Tab. VII

	Period			
	I	II	III	IV
Number of cases	29	202	89	19
Days from foundation to completing	3.50	2.32	1.92	1.52

Mean time needed to destroy a completed basis (number of cases given in parantheses)

Tab. VIII

	Nests rebuilt latter on	Nest not rebuilt
Complete destruction	6.29 (7)	12.95 (24)
Damage (regression)	7.75 (8)	12.84 (13)

Some of the ready outer baskets got destroyed or damaged, mostly within five days from the day they had been completed. On following days the number of nests destroyed or damaged decreased. In the interval between 20 and 30 day after the nest had been built a slight increase in destruction was observed. Single cases of destruction were noted even after 50 days. Nests destroyed later were rebuilt much more rarely (Tab. VIII). A high proximity of the dates of damages and those of destructions of nests implied that both these phenomena were produced by the same, though still obscure, causes.

WEATHER CONDITIONS AND NEST BUILDING

Maximum number of nests which can be founded or completed per day is limited and dependent on minimum temperature of the day in question. This limitation is by no means absolute and obviously depends also upon the number of birds active at this time. During periods I and III, the days when maximum of nests founded per day (6 nests) was noted had a minimum temperature from −2°C to +2°C. In period II maximum number of nests (12 nests) was founded on a day of the similar temperature. The diagrams (Fig. 8A and B) show rather

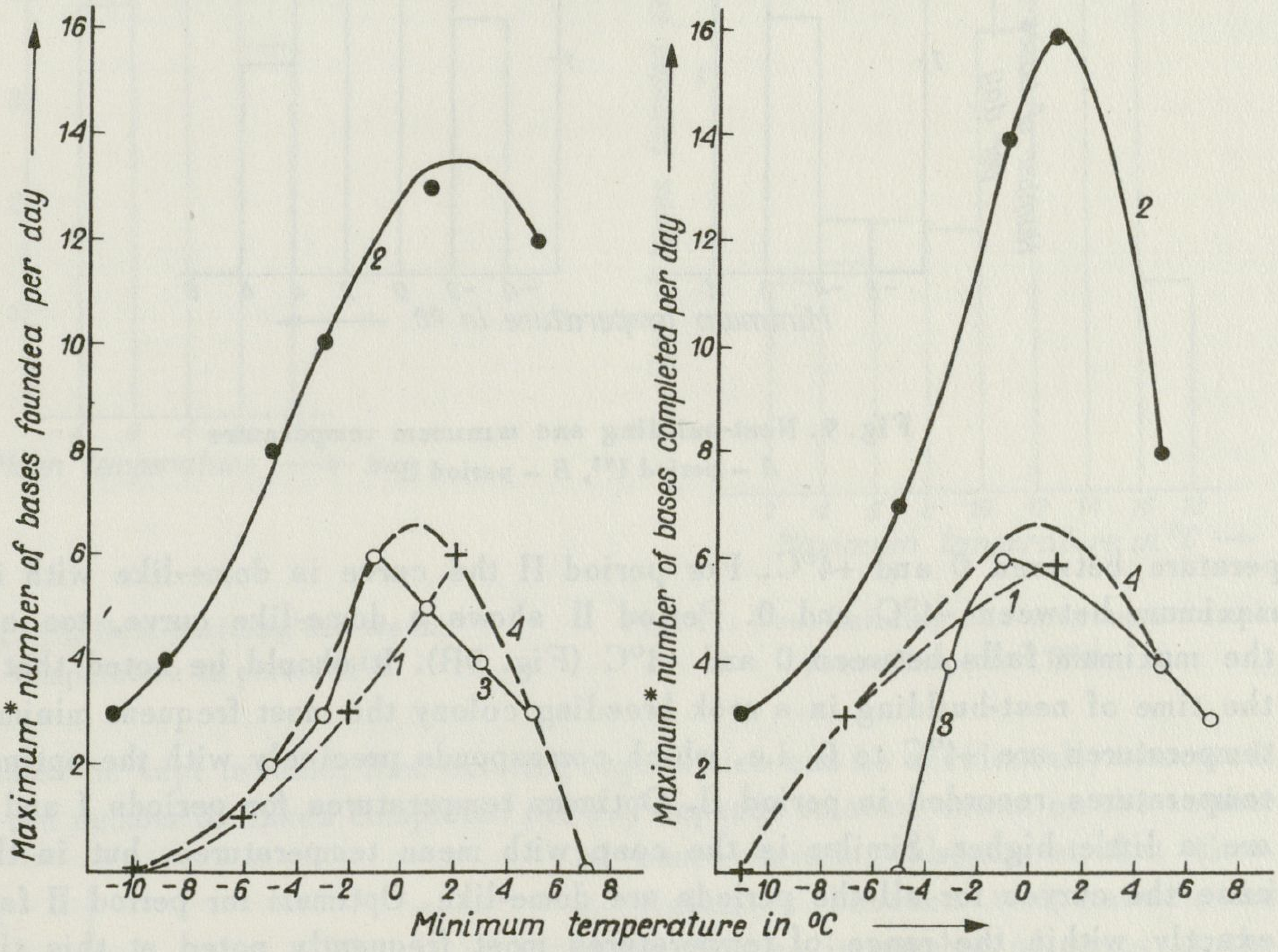

Fig. 8. Nest-building and minimum temperature
A – foundation of bases, *B* – completing of bases, *1* – period I[st], *2* – period II[nd], *3* – period III[rd], *4* – total of periods I[st] and III[rd]
*Maximum for each period for the years 1957–1960

precisely which are the minimum temperatures that form optimal conditions for the nest-building process. Similar diagrams with maximum and mean temperatures plotted were less distinct though showing the same dome-like shape. This is easy to understand since the highest building activity was observed early in the morning, when temperature was still low. So it seems that the morning minimum temperature is the strongest acting factor. The above discussed influence of minimum temperature can be demonstrated by plotting mean number of bases founded per day against minimum temperature of these days. In period I with the increase of temperature the number of bases founded per day also increased (Fig. 9A). The highest values were noted on days of tem-

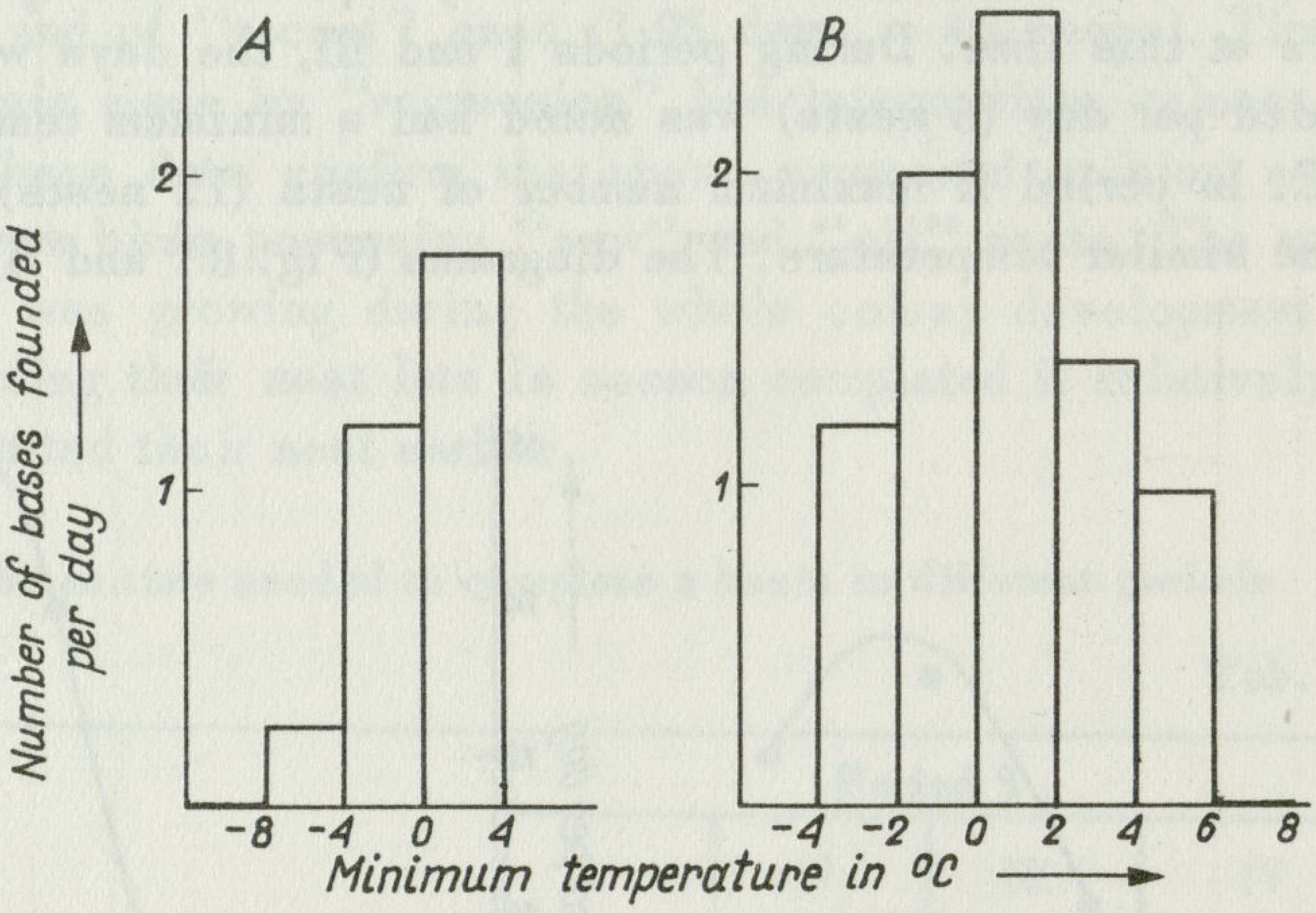

Fig. 9. Nest-building and minimum temperature
A – period Ist, *B* – period IInd

perature between 0 and +4°C. For period II the curve is dome-like with its maximum between -4°C and 0. Period II shows a dome-like curve, too and the maximum falls between 0 and +4°C (Fig. 9B). It should be noted that at the time of nest-building in a rook breeding colony the most frequent minimum temperatures are -4°C to 0, i.e. which corresponds precisely with the optimum temperatures recorded in period II. Optimum temperatures for periods I and III are a little higher. Similar is the case with mean temperatures, but in this case the curves for all the periods are dome-like. Optimum for period II falls exactly within the range of temperatures most frequently noted at this time (Fig. 10). Optima for periods I and III are similarly shifted by one rank higher. The influence of maximum temperature is not so conspicuous. Two optima can be seen, one in the range from 0 to +6°C and the second from +12°C to +16°C; and they both may occur simultaneously (period II) or only one at a time (Fig. 11). The maximum temperatures most frequent at the time of colony development range from +4°C to +8°C.

Similarly to the foundation of new nests, the destruction of them is also influenced to some extent by the thermal conditions during the day. A rise of minimum and or mean temperature causes an increase of number of nests destroyed per day (Fig. 12). No influence of maximum temperature was stated.

On the contrary, the number of bases completed per day does not show any correlation with the temperature. This distinct, though unexpected, result points out that even seemingly alike processes such as foundation of the nest basis and its completing may be controlled by different factors. Still,

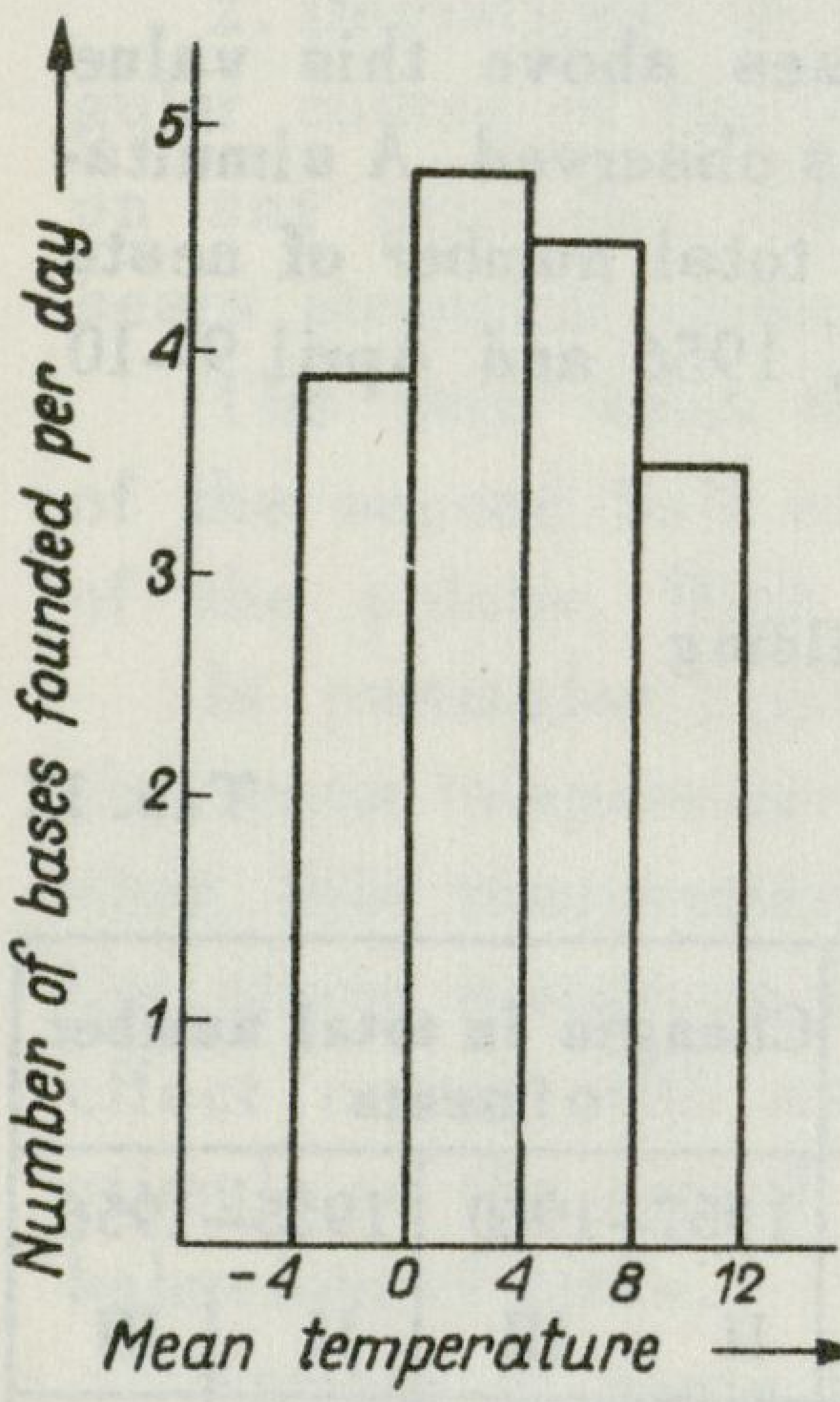

Fig. 10. Nest-building and mean temperature in period IInd

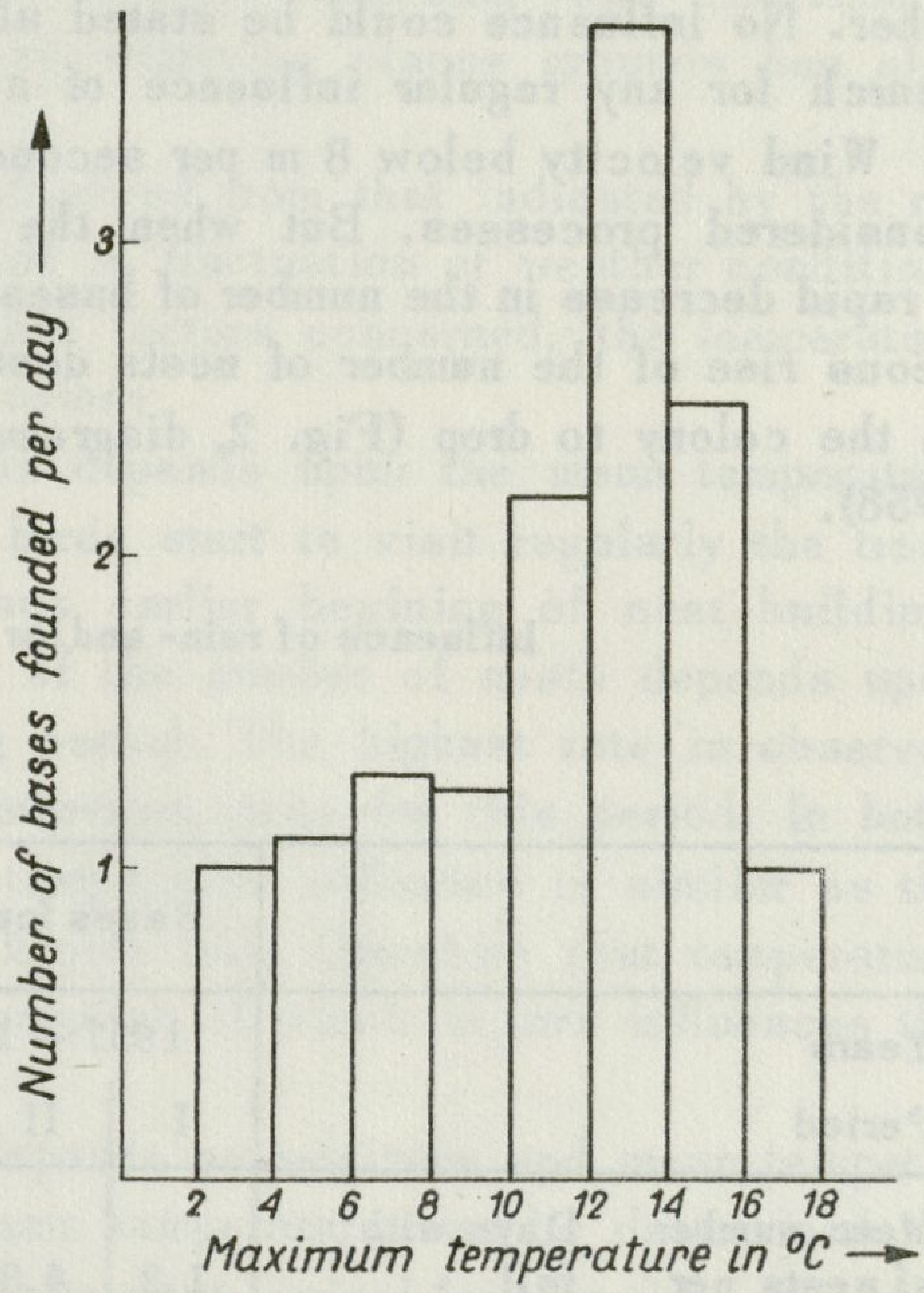

Fig. 11. Nest-building and maximum temperature in period IInd

it must be kept in mind, that existing regularities can be accidentally obscured, as the number of bases completed per day depends to some extent on the number of bases existing already at that time.

Relations between temperature and total changes in number of nests in the colony are similar to those between temperature and foundation of new nests, but because of the confusing effect of destructions they are less marked.

No influence of the rapidity of temperature changes or of 24-hour fluctuations was detected. The influence of air pressure is rather insignificant and results obtained for particular periods are not coincident. It seems that with a rise of air pressure the number of

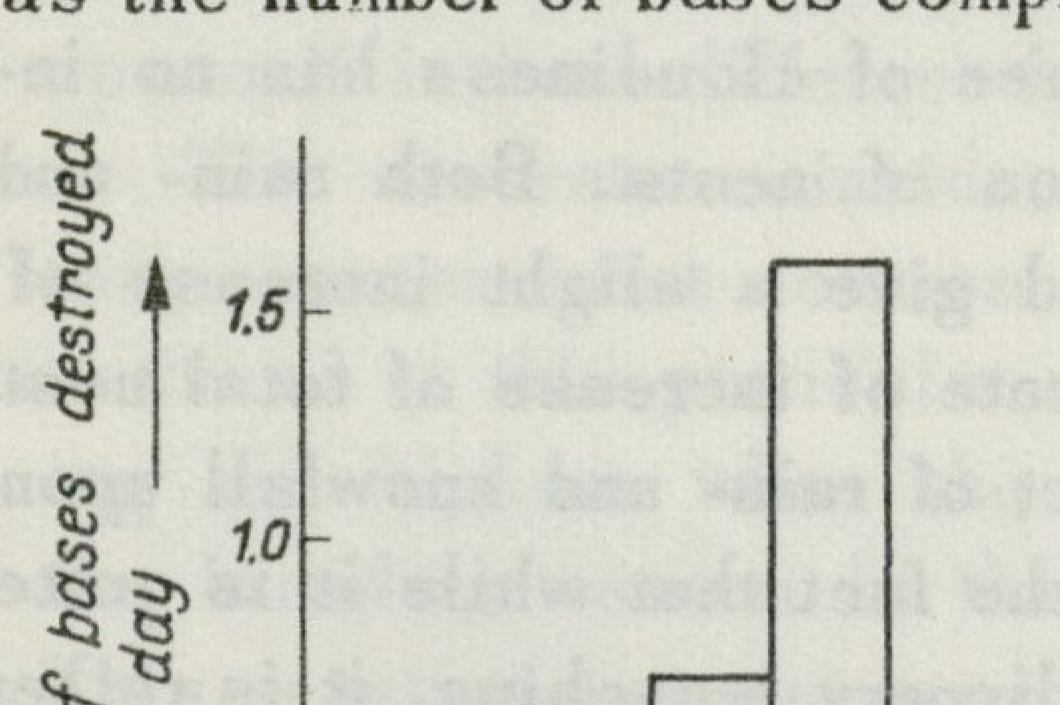

Fig. 12. Nest destruction and mean temperature in period IInd

bases founded per day also rises slightly. Still, this conclusion is drawn only from calculations for periods II and III which tally with changes in total number of nests during period II in the years 1955–1956. The results obtained as to the influence of air pressure upon nest destruction were contradictory to each other. No influence could be stated also upon the completing the nests. The search for any regular influence of air pressure changes was also in vain.

Wind velocity below 8 m per second have no effect whatever on any of the considered processes. But when the wind velocity rises above this value a rapid decrease in the number of bases founded per day is observed. A simultaneous rise of the number of nests destroyed causes the total number of nests in the colony to drop (Fig. 2, diagrams show April 7–8, 1956 and April 9–10, 1958).

Influence of rain- and/or snowfall of nest building

Tab. IX

		Bases founded			Destroyed		Changes in total number of nests			
Years		1957 – 1960			1957–1960		1957–1960		1955–1956	
Period		I	II	III	II	III	II	III	II	III
Mean number of nests per day	Days with fall	1.2	4.8	1.7	0.8	0.5	4.1	1.2	7.1	1.9
	Days without fall	1.0	3.7	1.7	0.9	0.7	2.9	1.0	4.2	1.5
Difference		-16%	-23%	0%	+12%	+40%	-30%	-16%	-41%	-21%

The occurence or absence as well as the degree of cloudiness has no influence, neither on foundation, nor on destruction of nests. Both rain- and snowfall reduce the number of bases founded and give a slight increase of destructions which together does slacken off the rate of increase of total nest number in the colony (Tab. IX). The lack of effect of rain- and snowfall upon the completing the nests is most probably due to the fact that while it is quite difficult to fasten a wet, slippery twig in a wet, slippery branching, it is rather easy to stick it into an already existing tangle of other twigs.

SUMMARY

1. Diagrams depicting growth of the number of nests during the breeding time of a rook colony were found to be close to regular sigmoidal curves. This was a permise used to divide the time of colony development into periods.

Not all the factors influencing the shape and inclination of the curve or the relative size of its parts could be detected. Among those which are known there are the thermal conditions, the rate of nest-building during period I, and the number of nests which remained from the preceding year. The time of arrival of birds returning from far away wintering places grounds has also some effect.

2. Deviations of the nest number observed from that indicated by the regular course of the growth curve are due to fluctuation of weather conditions on any give day. Out of all the weather factors concerned, the temperature bears strongest influence on the rook colony.

The date when nest-building begins depends upon the mean temperature of the second half of February, when birds start to visit regularly the trees of the colony. High temperature causes earlier begining of nest-building.

In particular periods, the increase of the number of nests depends upon the mean temperature of the preceding period. The highest rate is observed when this temperature is close to a long-term mean for this period. In both the above instances the mechanism of temperature influence is similar as the effect comes with some delay. It is known from literature that temperature stimulates the growth of gonads, the secretion of which in turn influences the behaviour of birds.

Number of nests founded per day depends on minimum and mean temperatures of this day. In both cases optimum temperature can be determined. In period II this optimum temperature is the one most typical for this time. Optimum temperatures for periods I and III are a little higher than the respective mean ones. Direct temperature influence is manifested also in an increase of the number of bases destroyed per day after a rise of temperature. For these two processes the influence of the present temperature acting without any retardation was demonstrated. Hence the conclusion is drawn that probably the modus operandi is here different from that of the two processes discussed previously.

The accurate coincidence of optimum temperature of period II and of the temperatures most common at that time shows a very strict adaptation of rook to breed at this particular season. Obviously the chances of successful breeding are highest when the birds' response to weather conditions typical for the breeding season is the most advantageous one, i.e. active nest-building. This reaction is most pronounced among birds building their nests at the most typical time, i.e. period II. Adaptation of this kind must have arisen by natural selection.

Beside temperature also rain- and snowfall affect the founding of new nest bases, rendering it more difficult. Wind exerts a destructive influence only at velocities above 8 m per second.

3. Close scrutiny of nest-building processes revealed marked differences in the nest-building instinct development between birds which got possession

of old nests and those which started to build new ones. Birds occupying old nests delay much longer the rebuilding if the nest was destroyed than do birds deprived of a new nest. The completing of old nest takes also more time than that of a new one.

4. These results are in accord with the literature quoted (p. 1). It has to be assumed that temperature is an important "proximate factor" controlling the time and rate of nest-building.

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DYNAMIKA BUDOWY GNIAZD W KOLONII LĘGOWEJ GAWRONA (*CORVUS FRUGILEGUS* L.)

Streszczenie

Praca zawiera wyniki sześcioletnich obserwacji nad budową gniazd w kolonii gawronów położonej na ruchliwej ulicy w Warszawie (Fig. 1). Gniazda budowane były

na topolach. Ilość gniazd wahała się od 75 do 123. Szczegółowe obserwacje przeprowadzono w ciągu czterech kolejnych sezonów lęgowych w latach 1957–1960. Codziennie notowano stan zaawansowania budowy każdego gniazda.

W budowie gniazda gawrona wyróżnia się trzy okresy: (I) powstawanie zewnętrznego, zbudowanego z patyków koszyka, (II) wzmocnienie budowli drobniejszym materiałem pomieszanym z ziemią i (III) ostateczne wysłanie wnętrza gniazda. W moich badaniach wyróżniałem dwie fazy możliwe do identyfikacji z ziemi: 1) początkową (podstawa) – każde dostrzegalne skupienie gałązek umieszczonych przez ptaki na drzewie, i 2) fazę wykończonej podstawy gniazda – od chwili, gdy przestawało prześwitywać przez nie niebo. Wyróżnienie tych faz dało możliwość rozpatrzenia następujących ewentualności występujących przy budowie gniazda:

1) niszczenie podstawy gniazda,

2) pozostawanie wolnego miejsca po zniszczeniu gniazda, a przed powstaniem na tym miejscu następnego,

3) wykończenie podstawy gniazda,

4) zupełne zniszczenie gotowego gniazda lub jego poważne uszkodzenie (regres do początkowego stanu budowy).

W pracy rozpatrzono prawidłowości rozwoju kolonii gawronów i czasu trwania poszczególnych faz budowy gniazda oraz przeprowadzono analizę wpływu warunków atmosferycznych na te procesy.

Rozpatrując wykresy (Fig. 2) obrazujące wzrost ilości gniazd w ciągu cyklu reprodukcyjnego w kolonii gawronów stwierdzono, że są one zbliżone do prawidłowych krzywych sigmoidalnych i wykorzystano tę właściwość kolonii do podziału czasu trwania jej rozwoju na okresy (Fig. 3). Wszystkich czynników wpływających na pochylenie krzywej i stosunki poszczególnych jej części nie udało się określić. Wśród przyczyn zmienności krzywej znajdują się warunki termiczne, efektywność budowy gniazd w I okresie rozwoju kolonii, oraz ilość gniazd pozostałych z poprzedniego roku. Również czas przylotu gawronów z odległych zimowisk może grać tu pewną rolę.

Odchylenia liczby obserwowanych gniazd od liczby gniazd przewidzianej przebiegiem krzywej są spowodowane zmiennością występujących w danym dniu warunków atmosferycznych. Spośród wielu rozpatrywanych w pracy parametrów meteorologicznych (temperatura, tempo zmian temperatury, wahania temperatury, ciśnienie, tempo zmian ciśnienia, zachmurzenie, opady, wiatry) największy wpływ na rozwój kolonii gawronów wskazuje temperatura.

Termin rozpoczęcia budowy gniazd zależy od średniej temperatury w drugiej połowie lutego (tab. I), kiedy to ptaki zaczynają regularnie pojawiać się na drzewach kolonii lęgowej. Wyższa temperatura w tym czasie powoduje wcześniejsze rozpoczynanie budowy gniazd.

Tempo powstawania gniazd w poszczególnych okresach rozwoju kolonii zależy od średniej temperatury w okresie poprzedzającym dany okres (tab. III). Największe tempo budowy gniazd obserwuje się wtedy, gdy termika okresu poprzedniego jest najbardziej dlań typowa. Prawdopodobnie w obu omawianych zjawiskach mechanizm działania termiki jest taki sam, gdyż w obu przypadkach reakcja na warunki termiczne charakteryzuje się pewnym opóźnieniem. Na podstawie danych z literatury można przyjąć, że działanie termiki polega na pobudzeniu czynności gonad, których sekrecja wpływa z kolei na zachowanie się ptaków.

Ilość powstających gniazd zależy od temperatury minimalnej i średniej w danym dniu. W obu przypadkach istnieją optima temperatury (Fig. 8, 9, 10). Optymalne wartości temperatury dla II okresu rozwoju kolonii pokrywają się dokładnie z najczęściej występującymi w tym czasie warunkami termicznymi. Optima temperatury w dwóch pozostałych zasadniczych okresach są nieco przesunięte w kierunku temperatur wyższych. Dla temperatury maksymalnej zależności te nie są tak jasne (Fig. 11). Bezpośrednie wpływy termiki wyrażają się również w zwiększeniu ilości zniszczeń podstaw przy wzroście temperatury (Fig. 12). W dwóch ostatnio omówionych procesach wykazano wpływ aktualnie istniejącej temperatury. W obu przypadkach nie występuje opóźnienie reakcji i z tego względu można przypuszczać, że mechanizm działania jest tu inny niż w poprzednio omawianych zjawiskach. Duża zbieżność optimów temperatury dla II okresu z najbardziej typowymi w tym czasie warunkami termicznymi świadczyłaby o bardzo ścisłym przystosowaniu gawronów do gniazdowania w określonym czasie. Należy uznać, że dla gawronów temperatura jest ważnym „czynnikiem bliższym" (Baker 1938) określającym czas i tempo budowy gniazd.

Oprócz temperatury wyraźny wpływ na zakładanie nowych podstaw mają opady, utrudniające tę czynność (tab. IX). Wiatr niszczy gniazda dopiero przy szybkości powyżej 8 m/sek. Wzrost ciśnienia ma minimalny wpływ na zwiększanie się liczby powstających gniazd. Nie stwierdzono wpływu innych parametrów meteorologicznych.

Z powstających na drzewach początków nowych podstaw gniazd średnio 22% ulega zniszczeniu, najczęściej następnego dnia po powstaniu (Fig. 5). Największy procent podstaw ulega zniszczeniu w I okresie (82%), najmniejszy w okresie IV. Średni czas wykańczania podstaw w poszczególnych latach jest odwrotnie proporcjonalny do tempa pojawiania się nowych gniazd (tab. VI). Tempo wykańczania podstaw rośnie w ciągu całego cyklu rozwoju kolonii.

Rozpatrując szczegółowo procesy występujące przy budowie gniazd, stwierdzono występowanie wyraźnych różnic w rozwoju popędu do budowy gniazda u ptaków, które objęły w posiadanie gniazda zeszłoroczne, w stosunku do osobników rozpoczynających budowę od nowa. Ptaki, które miały stare gniazda, znacznie dłużej zwlekają (średnio 11 dni), w przypadku zniszczenia gniazda (Fig. 6), z jego odbudową niż ptaki, które utraciły gniazdo nowe (średnio 4,20 dnia). U osobników tych wykańczanie gniazda (Fig. 7) trwa dłużej (2,88 dnia) niż normalnie (2,09 dnia). Autor uważa, że w obserwowanej kolonii do budowy gniazd przystępowały niektóre niedojrzałe płciowo osobniki.

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