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Zygmunt GRODZIŃSKI

The annual life cycle of Rooks *Corvus frugilegus* LINNAEUS, 1758 and Jackdaws *Corvus monedula* LINNAEUS, 1758 in the town of Cracow

[With 9 text-figs.]

Roczny cykl życiowy gawronów *Corvus frugilegus* LINNAEUS, 1758 i kawek *Corvus monedula* LINNAEUS, 1758 w mieście Krakowie

Abstract. Rooks and Jackdaws form loose groups in the Cracow area all the year round except for the breeding season proper. They roost together and then fly in groups to their feeding grounds, proceeding by separate but constant routes. The breeding birds roost in the centre of the town, in the town gardens called "Planty". An attempt was made to explain this choice of roosts by their favourable microclimate. The gradual foundation of pre-roosting places in the "Planty" is presented. The moment and manner of the abandonment of the roosts by the breeding birds on 12 October was observed. The reasons why Jackdaws build their nests much later than do the Rooks have been reduced to their method of providing themselves with building material. The setting-in of groundfrost brings about an invasion of Rooks and Jackdaws in the built-up areas to the town, in search of food. The birds clearly prefer places abounding in food and having convenient observation posts. The intensity of invasion increased each time with the increase in frost and in the thickness of snow layer.

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I. PROBLEM

Jackdaws and Rooks form loose groups of birds whose abundance and behaviour draw much more attention of inhabitants of Cracow than does the presence of Sparrows, Tits, Blackbirds and Starlings. Only half-wild Pigeons

and half-tamed Collared Turtle Doves are involved in more stable but at the same time more monotonous way in the picture of the town. Observation of the life of Rooks and Jackdaws, two closely related corvid species, all the year round permits the statement that they have many characteristics in common, but also differ much in their ways of life.

Numerous publications illustrate various aspects of life of these birds in the territory of Poland. The most abundant information has been gathered about the distribution, origin and decline of rookeries, considerably less is known about the nesting of Jackdaws (e. g. BOCHEŃSKI and HARMATA, 1962; DYRCZ, 1966; BERESZYŃSKI, 1974). WATERHOUSE (1949) and BUSSE (1969) were interested in their migrations and attitude towards people, while PINOWSKI (1959) and partly also BUSSE (1962) described large sections of their annual and daily life cycles.

Present observations were carried out in the closely built-up areas of Cracow to deepen and widen several problems signalled above. These are: nesting, choice of roosts and, in connection with them, flight to feeding grounds, as well as the penetration of wintering birds deeper and deeper into the down-town areas. An attempt was made to express the results of some observations quantitatively. Attention was also given to the behaviour of birds in flocks and efforts were made to find the causes of some kinds of their conduct. The behaviour of Rooks was compared with that of Jackdaws to find differences, which were, whenever possible, referred to the environmental factors and to the physical and psychical aptitude of birds themselves. The observations of behaviour were related to photoperiodism and internal biological clock.

II. NESTING

Rooks' nests, made of branches in still leafless trees early in the spring, are the more conspicuous, since their building is accompanied by a loud hubbub of builders. In Cracow there are more than thirty rookeries, widely scattered all over the town area. In 1975 I counted a total of 1150 nests in them. Assuming that young were reared only in 900 undamaged nests and that, according to OWEN'S (1959) indices, their clutches numbered 4.3 eggs and the mortality of nestlings was 30%, 2580 birds had been reared. Thus, including their parents, there were presumably 4380 Rooks that year.

Out of the nearly 300 nests of Jackdaws observed by KULCZYCKI (1973), 163 were in tree-holes and nest-boxes, 78 in buildings, 57 in rock crevices and only one, detached, on tree branches. The nests of Jackdaws are thus less conspicuous than those of Rooks. The easiest way to find them is by watching the birds carrying building material in beaks. Jackdaws do not betray the location of their nests by a din, either. Thus, it is difficult to determine, even only in approximation, the number of these birds nesting in the area of Cracow.

In the years 1971—1975 the Rooks in Krakowski Park began to build nests for good in the second decade of March. The building season proper ended before mid-April, but some belated pairs were still joining the colony towards the end of this month (GRODZIŃSKI, 1976). In 1976 two factors influenced this period of Rooks' life. Temperatures above zero, prevailing from mid-February and exceeding $+5^{\circ}$ at noon during 9 days, probably hastened the beginning of the building season. As early as 8 March the number of nests under construction began to increase at an ordinary rate. Sudden snowfall, which covered the ground with a 20-centimetre layer and left downy caps on tree-branches, interrupted building for four days (20—23 March). At first the birds attempted to break off snow-clad branches, but they soon gave up. They also found it difficult to pull out grass and tried to nibble it only in one place where it stuck out of the snow between stones. They did not resume work till 24 March, when the snow-caps had disappeared. A few late nests were built after 3 April, the last one on 27 April.

The Jackdaws started building their nests much later than did the Rooks. According to occasional observations, they were frequently seen with nest material in their beaks during the first two decades of April (1972, 1974, 1975). Their work at nest building in 1976 presented itself, according to systematic observations, as follows: still about 10 March the Jackdaws, in close groups of several dozen to a hundred specimens, headed the flight by the route over observation point No. 1 (Fig. 1). About 25 March particular pairs of birds occupied nesting regions and fed in parks, gardens and courtyard in their vicinity. The first Jackdaw with a stick in its beak was seen on 30 March. From this day onwards pairs of flying Jackdaws, only one in each pair with some building material in the beak, became more and more frequent. Pairs searching open lawns and dug plots of the park floor under the trees were also observed. The highest intensity of this stage fell in the period from 4 to 13 April, but towards the end of this period single specimens began to appear in the study area. Some of the nests must have been ready then and the females incubated eggs in them. Starting from 21 April only single birds appeared in Cracow, whereas at Sidzina in the Carpathian Mts., about 70 km south of Cracow, the building season of Jackdaws began to intensify as late as 14—20 April.

A comparison of the observations from the Cracow area show that Jackdaws begin building nests about 20 days later than Rooks do and that their building season lasts shorter than in Rooks. However, the building season of Jackdaws in the mountainous region (Sidzina — 572 m a. s. l.) is much behind time as compared with that in Cracow (220 m a. s. l.). This is certainly connected with the fact that the winter season lasts longer in the mountains. Between 4 and 13 April there were still thin strips of snow on slopes, below the forest edges.

Their manner of gathering material for nests throws some light on the reasons why these two species of birds, related to and much resembling each other in their ways of life, start building at different times. Rooks build their nests

in the form of a stout cup of branches varying in thickness and line them with tufts of grass pulled up by the roots with the beak. They break off branches with their beaks quickly and without fail. If they have lost a broken branch while making the cup, they do not pick it up from the ground. In consequence, there are always some branches of various thickness lying under the tree with

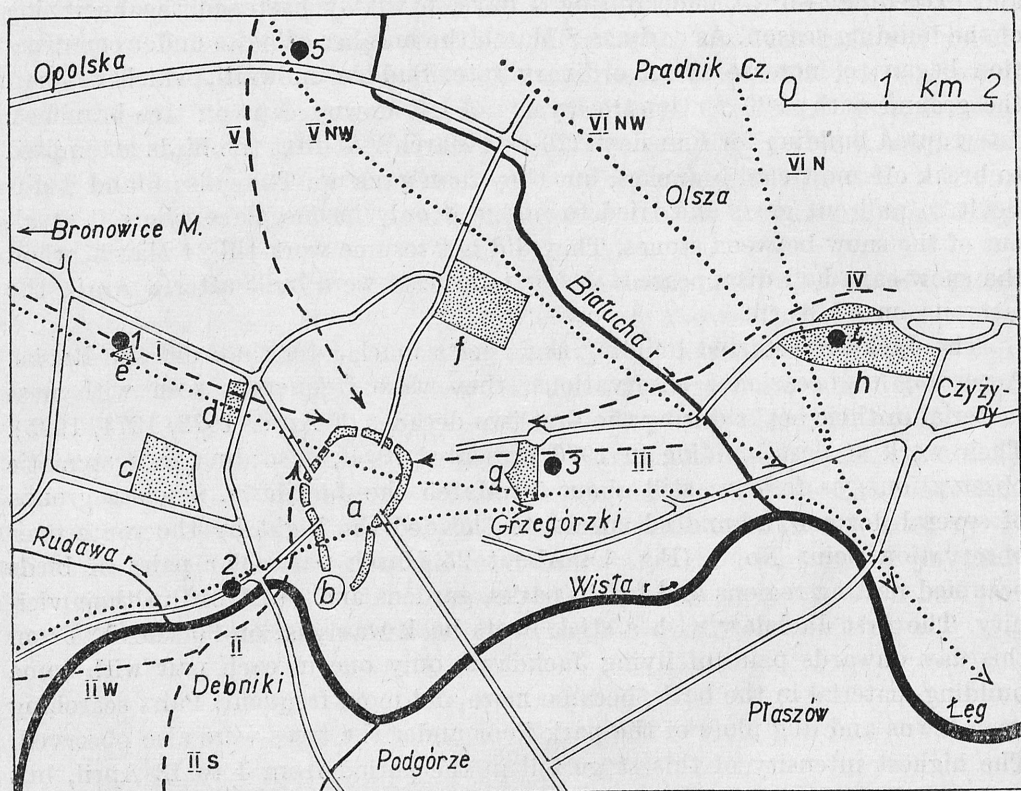


Fig. 1. The distribution of five points (1—5) from which the evening flights of birds from their feeding grounds to roosting sites were observed. Greens dotted. The flight routes of breeding birds, marked with broken lines, lead towards the Planty, where their rally takes place. The flight routes of wintering birds, marked with dotted lines, lead to Łęg and Mogiła. a — town centre surrounded by the Planty, b — Wawel Hill, c — Jordan's Park, d — Krakowski Park, e — Polewka Square, f — cemetery, g — Botanical Gardens, h — Park of Culture and Recreation

a colony of nests. Some dozen hours after their removal new branches were again found on the ground. KULCZYCKI (1973) writes that branches, freshly broken away, 0.5—2 cm in diameter and 20—50 cm long, formed 70% of the cup material. At the outset of the building season Rooks demolish the unoccupied nests of the last year (GRODZIŃSKI, 1976). In 1977 they demolished a newly started nest during a blizzard on 22 March.

Neither do they mind using the material from Magpies' nests. In 1976 there were four perfectly well preserved nests of Magpies at the route under study

in the zone of Rooks' invasion to the closely built-up districts. Three of them had been completely dismantled by the Rooks and the fourth one was left untouched. This was done in the second half of February and the first days of March and then at the time when some Rooks were more keenly concerned with their nesting sites and the other ones were getting ready for departure. In the case of two nests the Rooks took branches without paying attention to the presence of the Magpie, which was sitting quietly and motionless not far from the nest in the same tree. Some time later a new nest appeared in the place of the destroyed one. (It is worth noticing that in 1975 the Rooks dismantled a Magpie's nest in the same tree as early as the end of January and the Magpies built a new one about the middle of March).

The structure of Jackdaws' nests is very various, according to the shape and size of the space they are to inhabit. In roomy places (chimneys, vertical tree-holes) they put down a base of twigs and sticks and on it they place the cup proper of clay and lining composed of material of vegetable, animal and industrial origin. In narrow nooks the proportion of twigs decreases in a various measure up to their entire elimination (KULCZYCKI, 1973). Unlike Rooks, Jackdaws are rarely seen, to tear off twigs from trees but they assiduously seek short sticks, twigs, wood splinters, bark, straw or dead leaves under trees in gardens or in farmyards in villages. In newly ploughed and harrowed fields they gather roots of cereals, tufts of couch-grass and other vegetable parts. They pick them up with their beaks from the ground without effort and fly with their booty to the nest. If a pair succeeds in search somewhere, other pairs come immediately and work in harmony forming groups of 6—14. They begin building nests more or less an hour after sunrise. In the afternoon the intensity of work decreases and it is eventually given up long before sunset.

Rooks use force to acquire material for nests. They tear off branches with their powerful beaks and, drilling with them in the earth, pull up plants. Jackdaws are furnished with a shorter and weaker beak and use it mainly to pick up nest materials from the ground. As regards Rooks, the main framework of the nest cup is of branches, which they can break off even on frosty days. On frosty days with a thin layer of snow they can also pull up the grass by the roots, with earth clung to them. On the other hand, Jackdaws pick up their material from the ground only when it is not frozen to it or covered with snow. Different methods used by these two species to provide themselves with building material are decisive in regard to the fact that Rooks build their imposing and strong nests earlier in the spring, whereas Jackdaws to this later and at that their nests are carelessly fudged.

In both these bird species the eggs laid are incubated exclusively or nearly exclusively by females (YEATES, 1934; MAKATSCH, 1957; SOKOŁOWSKI, 1958), fed by males in this period. Male Rooks do not roost in the nest but in its close vicinity. Male Jackdaws do not roost in nests, either. In Cracow they gather in large groups in the "Planty". In 1972 I saw small groups of Jackdaws perching at the top of trees on both sides of Sienna St. an hour before sunset to-

wards the end of April (Fig. 2-R). Similar aggregates of birds were observed in the same place around mid-May in 1974 and 1975. Presumably, they were just the males.

In 1976 I carried out special observations in this area (Fig. 2-R) at regular 10-day intervals, starting from the last days of April. I used to go through the eastern part of the Planty loop each time (Fig. 2) about 70 minutes before sunset. The Jackdaws had already begun to gather there over a section of about

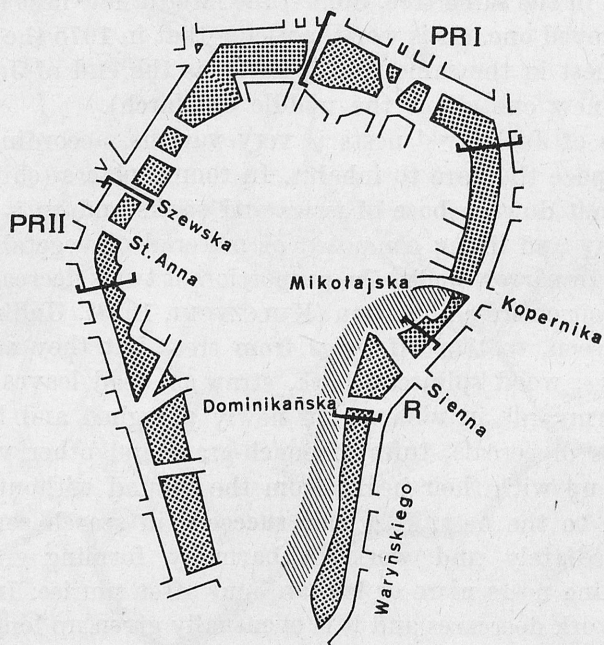


Fig. 2. Diagrammatic map of the Planty in Cracow, showing the roosting (R) and pre-roosting (PR) sites of Jackdaws and Rooks. The indent in the last terrace of the Małopolska Upland, raised above the roosting site and sheltering it against winds, is hatched

800 m, but only at the tops of trees still leafless, and then chiefly in ash- and acacia-trees. New birds joined them for about forty minutes then and at the same time those already present began to come nearer, reducing this distance to a third of its original length. Finally, they all flew over to the roosting trees, also in the Planty.

I closely observed a proper rally on 16 May 1976. The birds began to gather together in three young acacias, growing beside each other in a row and in an imposing ash-tree, a hundred steps away from them. This group of trees was divided by a street with a tramway (Fig. 2, Dominikańska St.). An hour before sunset there were 8 Jackdaws in tree a, 60 in b, 10 in c and 80 in d. These numbers changed incessantly, since new Jackdaws came and those perching in the trees moved elsewhere. During half-an-hour's period there was a moment when the number of birds in the three acacias decreased considerably, but

soon it exceeded the original number, e. g. in tree b there were as many as 120 birds. At the same time eight birds appeared for the first time on the roof and more than a hundred in leafless trees close to the monasterial garden-wall. New birds came flying again and again singly, a few together or in larger groups. This was accompanied by a conspicuous hubbub. A few minutes before sunset there were 350—400 birds within the range of my vision. After some dozen minutes of relative silence and quietness the birds began to fly away in small groups just above the tree-tops to their roosting sites in two opposite directions, to the east and to the west. The last few Jackdaws disappeared from the acacias and the roof 35 minutes after sunset. The western roosting site was situated in a group of chestnut-trees with well-developed foliage at a distance of about 300 m from the acacias in the Planty. The eastern roosting site was a few tens of steps away from the acacias and consisted of an imposing chestnut and two other leaved trees close to it. The subsiding voices of Jackdaws were still heard at both roosts for some time.

The rallies of Jackdaws observed on 26 April and 4 May 1976 took a similar course only that fewer birds alighted on the roof and they appeared somewhat later. The roughly estimated total of Jackdaws was similar, too. Most birds roosted at the western site.

The mode of Jackdaw rallies for roosting was formed throughout May. Leafless trees or only large naked branches in a definite section of the Planty were inviting to these birds as a potential rallying site. A roof or, later, in June, several ones served this purpose secondarily (Fig. 2, Waryńskiego St.). Jackdaws began to come flying singly, a few together or in small groups more than an hour before sunset. Up to approximately 400 specimens gathered here. At my fourth visit it was impossible to determine their number even quite roughly, because alighting in the trees and flying from one tree to another the birds disappeared among their leaves. Nothing can be said about the size of the region they were coming from, either. They roosted at two sites, the eastern and western. In April they moved in little groups chiefly to the western roosting site before sunset. In May this happened successively 17, 29 and 26 minutes after sunset, but gradually more and more Jackdaws roosted at the eastern site. At the same time stronger and stronger ties of community developed in the rallying birds, which was expressed by the fact that the groups flying from tree to tree were more and more numerous; eventually, all the Jackdaws flushed simultaneously.

There are a few considerations supporting the supposition that this is just where the male Jackdaws roosted. Above all, it cannot be assumed that so many (400) one-year-old Jackdaws, 'engaged' or bound up in established pairs (LORENZ, 1975) but still hormonally unfitted for breeding, were present in Cracow. Even if we took for granted that they were some indefinitely established pairs, their behaviour denies this. They came to the rallying site singly or in small, unnecessarily even groups and perched in trees or on roofs apparently apart from each other and not right beside as pairs usually do. In the breeding

season females cannot partake in such rallies because they sit in nests continuously. Males do not roost with females, there being hardly any room for them in the nests. Unlike male Rooks, they are not seen in the close vicinity of the nest in the evening, either.

The only possibility left is that here rallied males of breeding pairs from an indeterminate area. The evening rallies of small groups of Jackdaws in the Planty in the breeding season have already been observed by WASILEWSKI (1962) but their structure has not been commented on, nor have their causes been analysed.

In 1977 I resumed observation of the roosting of male Jackdaws in the Planty; it as a rule confirmed the data obtained in the preceding years and concerning both the place and the mode of sinking for roosting. The new data are 1. the date of the first appearance of the roosting Jackdaws (21 April), 2. the finding that at first (21, 29 April) the groups of Jackdaws that had gathered in the Planty roosted somewhere out of them, 3. the fact that flocks of Jackdaws did not fly from the rallying site to the western roosting site, between Sarego St. and the Monopol Hotel in the Planty, before 9 and 21 May and 4. that in June (6 June) they at last roosted in the rallying site, together with a small number of Rooks.

These three stages that show the Jackdaws that rally in the Planty gradually adopt a mood for gregarious roosting at the eastern site. This process was observed three times year in year out. The memory fixed at the level of flock obviously governs the choice of rallying sites and then those of roosts. The older specimens, familiar with the region, surely lead the remaining Jackdaws.

III. ROOSTS

In the summer months the breeding Jackdaws and Rooks of Cracow gather together in two pre-roosting sites in the Planty, from where, not before sunset, they fly to the roost also in the Planty, between Sienna St. and Dominikańska St. (Fig. 2-PR, R). They roost there for several months to move to the groves on the Vistula about mid-October. There, at Łęg and Mogiła, they roost more or less from mid-October to March (GRODZIŃSKI, 1971). Casual observations in 1971—1974 and systematic ones from the autumn of 1975 to the summer of 1976 permit keen insight into the roosting habits of these birds. The Planty, which play so important a part in this period of life of Rooks and Jackdaws are a very specific park of Cracow. They were founded in the first half of the nineteenth century in the place of the mediaeval fortifications, which had been pulled down and the ground levelled. Forty years later, about 1850, they occupied their present area and were bordered by new (KLEIN, 1914) streets. Naturally, in course of time the composition of the stand and the roads of inner traffic have undergone changes. However, their shape of a loop enclosing the town, centre, as the defensive walls did in the past, has remained unchanged.

From 26 April to 26 May the roost in the Planty (Fig. 2-R) slowly became crowded. Only Jackdaws, presumably males, which roosted communally, leaving the females incubating in tree-holes and wall-recesses for the night, arrived here before sunset. Voices of Rooks could be heard in the neighbourhood of their several nests in this region; these were either juveniles sitting by the nests in which they had been raised or simply whole families returning to their trees for roosting. Little groups of such Rooks flew from the west.

During June 1976 two important changes occurred in this roosting system. Two pre-roosting sites developed gradually and there appeared slowly increasing numbers of Rooks roosting together with Jackdaws. As late as 5 June in the pre-roosting areas Rooks uttered voices only in some nesting trees, whereas Jackdaws could not be seen either in trees or on roofs. Ten days later the first small groups of Jackdaws appeared at both pre-roosting sites. After another five days (19 June) in the western (secondary) section 12 Jackdaws perched in a poorly leaved lime-tree, while several Rooks called in trees between St. Anna St. and Szewska St. A small group of Rooks gathered in the eastern (primary) section (Fig. 2-PRI, PRII), single birds flying continually from one tree to another. Inspections on 25 and 30 June showed a considerable increase in the number of birds at both pre-roosting sites. In the western section the number of Jackdaws had at least doubled and the voices of Rooks were sonorous. In the eastern section the Jackdaws, about 100 in number, gathered on the roof of a neighbouring house and partly in the trees together with a noisy group of Rooks. A few minutes after sunset small or somewhat larger groups of Jackdaws and Rooks often flew over the eastern section in the Planty, from the north towards Sienna St. (Fig. 2-R). The birds that had gathered in the eastern section of the Planty flew away in a close group also in the direction of Sienna St. more or less at sunset.

More and more Jackdaws and Rooks gathered at the roosting site proper in June, but as the birds alighted mostly in well-leaved trees, their number could not be determined. At any rate, in the first half of this month Jackdaws decidedly predominated as regards number. The Rooks initially came flying from various directions in groups of 2—4. However, it was only on 19 and, especially, 25 and 30 June that larger groups of Rooks arrived, mainly from the east, and at once sank for roosting in trees growing mostly between Sienna St. and Dominikańska St.

During July and August more and more birds gathered at the pre-roosting sites and they flew away to the roosting site later and later. As a result, fewer and fewer birds came here direct and thus on 23 August 1975 only a few Jackdaws were sitting on the roofs at sunset and a few voices were coming from the trees close to Sienna St. It was not until five minutes later that flocks of Jackdaws and Rooks, varying in number, began to arrive; they circled over the trees and slowly alighted in them. Arrivals, including those of Jackdaws from the roofs, were completed in ten minutes. In July and August the number of Rooks increased clearly as compared with that of Jackdaws. It may be

roughly estimated that they formed a half of the roosting flock. In September the time of the pre-roosting rally was decidedly established and distinctly separated from the time of sinking for roosting.

The invading of the main pre-roosting site by Jackdaws and Rooks lasted an hour at least and ended right at sunset or a few minutes after it. Small and large groups of birds came flying from various directions at this time and

Table I

Behaviour of Rooks and Jackdaws at the pre-roosting site (Fig. 2, PR) on 6—12 October 1975 relative to the time of sunset. Stage I — mass arrivals at the site of pre-roosting rallies; stage II — subsidence of voices and flights from tree to tree; stage III — flights to roosts

| Date 1975 | Sunset | End of stage | | |
|------------|--------|--------------|-------|-------|
| | | I | II | III |
| 6 October | 17.10 | 17.10 | 17.28 | 17.32 |
| 9 October | 17.03 | 17.12 | 17.20 | 17.28 |
| 10 October | 17.01 | 17.12 | 17.21 | 17.27 |
| 11 October | 16.58 | 17.05 | 17.10 | 17.15 |
| 12 October | 16.57 | — | — | — |

settled in trees. This was accompanied by a noise of voices and continual flights between trees. At last the birds assembled more and more closely in this visibly decreasing section of the Planty. At the second stage the voices of birds quieted down gradually and the flights between trees became rarer and rarer. This lasted several to more than ten minutes, when the birds were getting ready to start for the roosting site proper.

Conjectures might be made as to what eventually induces the quietly perching birds to flush from the trees. Is this a manifestation of some external stimuli, measurable in luxes or minutes, or do the birds make a conscious decision on the basis of their experience and memory? Anyway, not all the members of the aggregation showed the same state of readiness. A beginning was always made by small groups that flushed and flew in the direction of their destination. Some of them returned to their places. At last a large group took wing and induced the remaining birds to follow. An example must act on a suitable scale and at an appropriate time. The scale is determined by the number of flushing birds and the intensity of sound signals: crowing and flutter of wings. The birds departed in 2—3 flocks, numbering hundreds of birds each and setting off immediately one after another. The final group, consisting of several dozen birds, most frequently Jackdaws, visibly delayed the flight. The whole departure took several minutes. During August and September this stage fell more and more behind compared with the time of sunset.

In the period of three critical days (Table I, 10—12 October 1975), which preceded the abandonment of the Planty by the breeding birds, great changes

occurred in the picture of rallies at the pre-roosting sites. On 10 October the birds still left the site of rally about 25 minutes after sunset, the subsidence of noise and departure taking about 15 minutes. The following day (11 Oct.) the pre-roosting rally was characterized by excessive and disorderly activity and prolonged hubbub. The subsidence of voices and departure lasted 10 minutes and the pre-roosting site was emptied 12 minutes earlier than the preceding day. Fewer birds seemed to gather there than usual among them, judging by voices, Jackdaws were more numerous. It may well be that some Rooks failed to come to the rally. Finally, on 12 October there was dead silence at the pre-roosting site, even during the ten-minute period around sunset. The birds had not rallied there at all.

The rally of birds at the pre-roosting site may be rather arbitrarily divided into three stages (Table II). In September (28 Sep.) before sunset small groups and single birds flew from various directions over the roosting section of the Planty, without alighting either in the trees or on the roofs. These flights may be called reconnoitring flights, preceding the arrival of the birds at the pre-roosting site. After sunset, their groups, increasing in size, came flying and circled over the Planty, making a great din; they united and then split into smaller groups, disappeared in part from sight and appeared again. This stage of flock raids lasted above 15 minutes. Later, the birds (Rooks and Jackdaws) began to settle in the trees and slowly grew silent (Stage III).

Table II

Arrivals of Rooks and Jackdaws at roosting sites (Fig. 2, R). Stage I — reconnoitring flights; stage II — flock raids and circling over trees; stage III — settling in trees

| Date 1975 | Sunset | Duration of stage | | |
|--------------|--------|-------------------|--------------|--------------|
| | | I | II | III |
| 28 September | 17:27 | 16:45— 17:15 | 17:30— 17:44 | 17:45— 17:55 |
| 5 October | 17:12 | — | 17:15— 17:25 | 17:30— 17:37 |
| 8 October | 17:05 | — | ? | 17:24—17:30 |
| 11 October | 16:58 | 16:58 | ? —17:25 | 17:28—17:30 |
| 12 October | 16:57 | 17:10— | 17:15—17:26 | 17:29—17:35 |
| 13 October | 16:55 | — | — | — |

I did not observe reconnoitring flights in October (5 Oct.), perhaps I began my observations too late, although still before sunset. On the other hand, thousands of birds participated in flock raids and circling. The settling of the birds in trees proceeded normally. Three days later the birds still sank for roosting in a typical way. On 11 October I observed that a rally full of excessive movement at the pre-roosting site was followed by the circling of birds with a hubbub over the roosting site and their sinking for roosting in a relatively normal way.

Lastly, on 12 October the birds took leave of the roosting site. Thirteen minutes after sunset a fairly large flock of birds appeared over the Planty and, without stopping, flew along Kopernika St. (Fig. 2). Five minutes later the birds began a raid upon the Planty with a usual hubbub. The circling was undecided; the large flock divided into smaller groups, which flew away and then returned again. Eventually, some of the birds alighted in the trees by the Dominikańska St. After a few minutes they flushed and flew to the east. At 7.40 only low voices of several Jackdaws sitting there and one Rook could be heard in the whole roosting section of the Planty. The behaviour of the flock that evening proves that two discordant tendencies clashed among its members, were they to roost in the Planty or to fly to the east. Some of the birds decided to give up their traditional roost instantly, others hesitated what to do. A part of the flock even tried roosting, but the example of the departing birds won; in the end all the birds followed them. Thus, the birds has as a rule been in the mood for changing their roost for several days, but their readiness to fly away ranged within wide limits.

On 13 October the roosting site was still empty 30 minutes after sunset. At that time several flocks flew over it at a medium height to the east, probably to Łęg (Fig. 1). The breeding Jackdaws and Rooks left the main pre-roosting site a day before their leaving the roosting site. At the second pre-roosting site, the western one, they still gathered for a few days. At any rate, they were still there on 15 October, when they, 250 in number, flew to south 10 minutes after sunset. However, they did not stop at the roost in the Planty. Five days later they did not collect at all.

Having checked that the birds had given up roosting in the Planty decisively on 13 October, the next day I visited the roosting sites at Łęg and Mogiła, known to me since 1969. Trails of birds began to pass over there 30 minutes before sunset, some flying to the east, toward Mogiła, some to the south, across the Vistula. A part of these last alighted in the region of Rybitwy in the trees on the right-hand bank of the river. The flights of more and more numerous flocks in many directions lasted after sunset only that many birds alighted beside those already sitting on the Vistula. Thus, a kind of site of pre-roosting rally developed here. From here and from other places, probably from Mogiła, the flocks began to come flying over a grove at Łęg and to circle over it with a great hubbub. They tried alighting in the trees and flushed again. Thirty to forty minutes after sunset they alighted more decidedly but many of them were still on the wing. Two persons, living near the grove, stated that the birds had not appeared there in flocks until 2—3 days before, i. e. when the breeding birds had left the Planty.

This was therefore the outset of the winter roosting site, where also migrants from the east stayed. In Warsaw the peak migrations occurs in the third decade of October and at the beginning of November (PINOWSKI, 1957). During several weeks following the period of autumn migrations in Cracow, the birds steadily roosting at Łęg and Mogiła form an aggregate, which splits into groups

foraging in Cracow and its environs in the morning and gathering together here for roosting. These are regular flights to feeding grounds and back to roosts. Observation on the number of birds flying over five observation points in the town shows that considerably more birds winter in Cracow than breed in it.

Two facts indicate that also breeding birds roost at Łęg all through the winter. BUSSE (1969) has calculated that 37% of our Rooks do not leave for winter and still more Jackdaws remain. During the winter, starting from mid-November, a small number of Rooks appear in the rookeries and look after their nests or their remains (GRODZIŃSKI, 1976). Rooks nesting in south-western England (YEATES, 1934; MARSHALL and COOMBS, 1957) and in Schleswig-Holstein (PORATH, 1964) behave similarly. However, this is an open question how many breeding birds winter at Łęg. As regards many birds coming for winter, it is not known if they arrive in one or a few groups and in which period of autumn migrations they come.

A puzzling question arises, why in Cracow Rooks and Jackdaws have been roosting for years in a definite section of the Planty or at Łęg and Mogiła. Their roosting in the Planty as a whole may be explained by the fact that after the breeding season the Rooks still roost near their nests, scattered in long sections of this Park, for some time. This group of Rooks simply do not leave their roosts in the Planty. On the other hand, male Jackdaws gather here for roosting in definite, less widely extending places. Thus the choice of the Planty for roosting is associated with breeding, but on different bases in either species. Moreover, the mass rallies for roosting begin much earlier with Jackdaws, towards the end of April, whereas in Rooks they begin in June.

The Planty section chosen by the birds as their roosting site is characterized by the virtue of being calm, so important to them, and in this connection by somewhat higher temperatures. Rooks are more susceptible of cool winds than are Jackdaws, which becomes very well seen in winter. On frosty windless days they sit high up in trees, but whenever the wind blows, they shelter on the snow-covered ground, in its depressions, behind earth embankments or house walls and in low trees well screened by other trees and houses. Crouching motionless, they remain there long, reacting sluggishly to the food offered. Jackdaws take shelter from winds chiefly in nooks of houses in winter and only very rarely on the ground.

The roosting site in the Planty is situated in the part of Cracow with the lowest number of days with strong winds, blowing mainly along the west-east axis, and the highest percentage (36%) of calm days (HESS, 1967). It occupies a basin-like depression cut out in the wall of the last terrace in the slope of the Małopolska Uplands. In the south-west the depression slopes gently towards the Vistula. The northern and eastern walls of the basin are formed by the hill "Na Gródku", including Mikołajska St. The extension of Wawel Hill, reaching as far as the Market Place, forms the western wall (TYCZYŃSKA, 1967). The natural edges of the basin are raised by the appreciable walls of houses built on them. All this constitutes an additional screen protecting the trees of this

section of the Planty from winds and creates a microclimate which is still more favourable and certainly the only one in the Planty, enticing the Rooks and Jackdaws to roost here. The other sections of the Planty loop, i. e. the north-eastern, northern and whole western sections, grow on the flat of the above-mentioned terrace. The relatively low buildings do not screen the trees from the prevailing winds. Thus there are no conditions for a Rooks and Jackdaws-favouring microclimate to arise.

In winter many Jackdaws in Sweden, Finland and Estonia roost in the centres of towns, where the temperature is several degrees higher than out of town. Some of them come flying from distances reaching 30 km. A comparison of energy spent for flight with the energy saved at roosts is favourable only in the case of birds flying from short distances. Other advantages of roosting in towns are protection against predators and acquisition of information about food (GYLLIN et al., 1977 and authors cited by them). SWINGLAND (1977) estimated Rooks' sensitivity to microclimate quantitatively and found that at changes in temperature and weather (wind, rain) occurring during a night the roosting Rooks move to lower and lower branches, where they find better conditions.

In the Planty the Jackdaws and Rooks leave their roosts about mid-October, which might be treated as preparation for autumn migrations, when they meet the migrants from the east. However, why do they move to the east from the Planty and not to the west or south-west, i. e. conformably to the route leading to their winter quarters? The only answer that occurs is that the western districts of Cracow and their adjacent regions have no suitably quiet and wooded sites for roosting. On the other hand, the groves at Łęg and Mogiła suit this purpose perfectly. This is proved by observations of migrating birds flying at close of day and stopping there in masses both in the autumn and in the spring (GRODZIŃSKI, 1971, 1976). These groves grow close to the embankment of the Vistula, less than one kilometre apart from each other. They are the lowest-lying group of trees in Cracow. Rooks do not build their nests, which might attract the passing birds, in them. The grove at Łęg consists of densely growing, relatively young trees; it is protected by the Vistula embankment on one side and a row of houses on the edge of the Vistula terrace on the other. The grove at Mogiła, made up of older trees growing on the flat Vistula terrace, is not so well screened from the sides. In both groves the faeces of the roosting birds cover the ground only in the central zone. This proves that the trees at the border do not suit the birds for roosting but from an additional protection of the grove centre against winds.

IV. FLIGHT ROUTES OF BREEDING AND WINTERING BIRDS

The roosting sites of Rooks and Jackdaws might be regarded as their habitations, from which every day before dawn they fly in various directions to their feeding grounds and where they return before sunset in the evening.

The duration of everyday flights was determined in 1968/1969 at one of the points of the route leading from the east westwards (GRODZIŃSKI, 1971). Now I was concerned with making a map of flights covering the whole territory of Cracow. For this purpose five observation points had been chosen not far from the town centre so as to allow observation of at least a 150-degree sector of the open horizon. The distance between the two remotest points in the east-west axis was 6.6 km and between those in the north-south axis 5.0 km.

The directions of flights and their presumable routes are illustrated in a topographical drawing (Fig. 1). Five observation points lie at various distances away from the town centre, enclosed by the ring of the Planty. The birds passing from the west were observed at point 1 — Polewka Square (2500 m away from the centre), the birds from the south and south-west at point 2 — by the Dębniki Bridge (1500 m), those from the east at point 3 — in the neighbourhood of the Botanical Gardens (2000 m), from the north-east at point 4 — in the Park of Culture and Recreation (5000 m) and from the north at point 5 — in Opolska St. (4200 m). As both roosting sites of destination lie in depressed parts of the territory, all the flight routes are always variously though slightly inclined downwards. The birds avoid all the elevations above the bottom of the Vistula valley, both the highest ones, Sowiniec (355 m) and the lowest, Wawel (245 m).

Observations made at these five points made it possible to establish the following flight routes to the roosting sites:

Route I is straight and similar for both breeding and wintering populations of birds. Its narrow track leads in a direction approximating the east-west axis, from the valley of the River Rudawa to the northern part of the loop of the Planty. Here it terminates for the breeding birds, whereas the wintering ones fly on over the Botanical Gardens to Łęg and Mogiła.

Route II consists of two branches as regards the breeding birds. The western branch runs between Sowiniec and the Krakowska Gate and the southern branch between particular blocks of the Krakowska Gate. These branches join together in the proximity of the Dębnicki Bridge, from where the common route passes round the Wawel Hill, west of it, to reach the roosting site in the Planty. The wintering birds fly only along the western route, over the old part of the town towards the Botanical Gardens, where this route joins Route I and they run together to Łęg.

Breeding Rooks and Jackdaws fly by route III from east towards the west forming a wide track over the Botanical Gardens to the Planty.

In the breeding season only few Rooks fly from Czyżyny in the east, where there had been a large rookery in the spring, over observation point 4 straight to the Planty (route IV). The wintering birds (Rooks and Jackdaws) fly in large flocks by several tracks, chiefly from the north-west. Near observation point 4 they join together (route VI NW) and go south to Łęg and Mogiła.

Route V, quantitatively similar for both groups of birds, consisted of several tracks running along the gentle slope of the Małopolska Upland to approach

each other over observation point 5. The breeding birds flew to the south to the Planty (route V) and the wintering birds turned south-east, flying more or less parallel to route VI NW.

The number of the flying birds, the direction of their flight, and the duration of the whole evening passage were recorded at observation points 1—5 (Fig. 1). Thanks to the determination of their times relative to the time of sunset, all the flights may be compared with each other regardless of the date of their occurrence. The flights of the breeding birds were observed in the third decade of September and thus in the period when they occurred in full and undisturbed rhythm, for they preceded the abandonment of the roosting sites in the Planty by at least a fortnight. On the other hand, the flights of the wintering birds were recorded in the first half of November, when their aggregation had already been completed and decidedly associated with the roosting site at Łęg and Mogiła.

Table III suggests three obvious facts: 1. considerably more birds (c. 9200) winter in Cracow than nest (c. 3800), 2. the intensity of flights over particular observation points differs conspicuously between these two groups, and 3. the

Table III

Numbers of birds flying over five observation points, marked on the map in Fig. 1

| Date of observation | Observation point | | | | | Total of birds |
|---------------------|-------------------|------|------|------|-----|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| 23—27 September | 1509 | 1259 | 603 | 62 | 387 | 3820 |
| 4—14 November | 751 | 434 | 4440 | 3187 | 393 | 9165 |

breeding and wintering birds show preference of different flight points, the former passing chiefly over points Nos. 1 and 2 and the latter over Nos. 3 and 4. The birds assuredly choose their feeding grounds according to the abundance of food in the given area and time.

The intensity of flights expressed by the number of birds flying in five-minute periods, is illustrated by graphs in which the reference point for comparisons is the time of sunset (Fig. 3—7). It is easy to read from them how many birds fly in similar periods of time over any observation point. It appears that 1. each flight curve has one or more peaks of frequency and flattened sections varying in length, especially at the beginning of the passage; 2. the height of peaks is proportional to the total of flying birds; 3. the peaks occur mostly towards the end of the curve and then near sunset, more rarely only in its middle and in one case they are scattered; 4. as regards the breeding and wintering birds flying over points 1 and 5 (Fig. 3 and 7), the curves as a rule have a similar shape and in the other three cases they are incomparable, and 5. the flights end just before sunset and only in two cases (wintering birds flying over points 3 and 4; Figs. 5 and 6) they are prolonged till 10 or 20 minutes after the time of sunset.

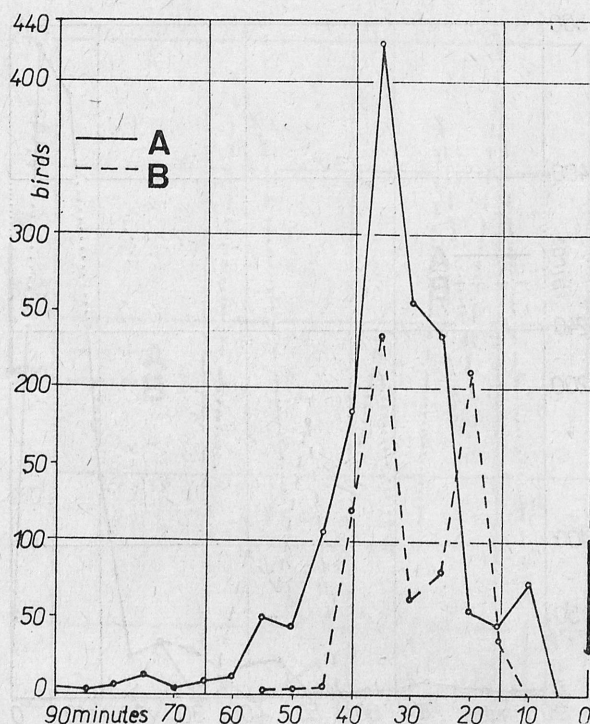


Fig. 3. Evening flights over observation point No. 1. Route I. Ordinates represent numbers of birds, abscissae the time of observation at ten-minute intervals in relation to the time of sunset assumed as the zero point (arrow). The solid line (A) represents the flights of breeding birds on 29 Sept. 1975 (altogether 1509 birds) and the broken line (B) the flights of wintering birds on 4 Nov. 1975 (751 specimens)

These observations indicate, above all, that in their initial phase the flights are made individually and later in organized groups. First, single birds, their pairs or small groups appear in the route; they go to the roosts by their usual track, without paying attention to what the other birds are doing. The flights of this type may last for 40 minutes but include only a low percentage (2—10%) of the birds flying on this day. This proves that these birds had not, as yet, developed the habit of gregarious flights in spite of their having used the same route for 3—4 months. In the initial periods in the regions of observation points 3, 4 and 5 single Rooks or their pairs always stopped and they fed there in large areas, unbuilt or with scarce trees. This took them from 10 to 25 minutes before they decided to resume flight towards their roosts. On the other hand, the birds alighting in trees close to these areas stopped there only for a short while. The state of adequate satiety, which co-works with the sociability of these birds, is perhaps one of the flight-releasing factors. Unsatisfied hunger may have an antagonistic effect. At any rate, Rooks begin their evening flights, showing some individuality.

The flights in groups and even in large flocks prove that the birds had gathered somewhere at the route. Such rallies were observed by GRAMET (1956),

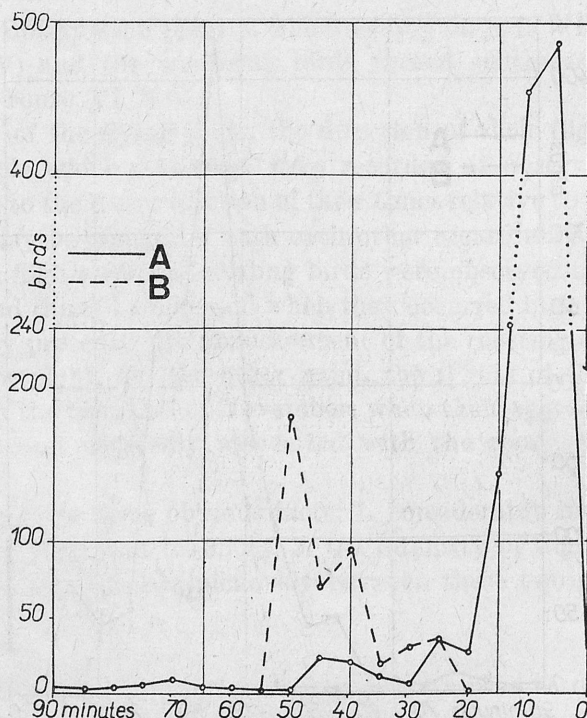


Fig. 4. Evening flights over observation point No. 2. Route II. For explanations see Fig. 3. Breeding birds: 24 Sept. 1975, 1259 specimens; wintering birds: 9 Nov. 1975, 434 specimens

PINOWSKI (1959), LINT (1964) and RAPPE (1964). The size of flocks ranged especially in November, from 120 to 500 birds (Routes III, IV, V and VI NW). The more birds fly a given route, the larger flocks they form. The flocks flying the same route at intervals of several minutes may have formed in its different sections and set out on the flight at such intervals that they failed to join each other. They may also have waited gathered in large flocks but started the flight in separate groups at different times. Similar behaviour can be seen in the sites of pre-roosting rallies.

V. INVASION OF WINTERING BIRDS IN BUILT-UP AREAS OF CRACOW

On 12 October 1975 the Rooks and Jackdaws left the roosts in the Planty and moved to Łęg and Mogiła, where a very numerous grouping of birds coming for winter was formed in the groves used for roosting. Early in the morning they flew from here by at least five routes to the feeding grounds situated chiefly in fields and meadows at various distances from the densely built-up parts of Cracow. Towards the evening they returned to their roosts following similar routes, their flights being watched from above-mentioned five observation points (Fig. 1). It was still to be determined when and to what extent the birds began to penetrate the built-up zone of the town.

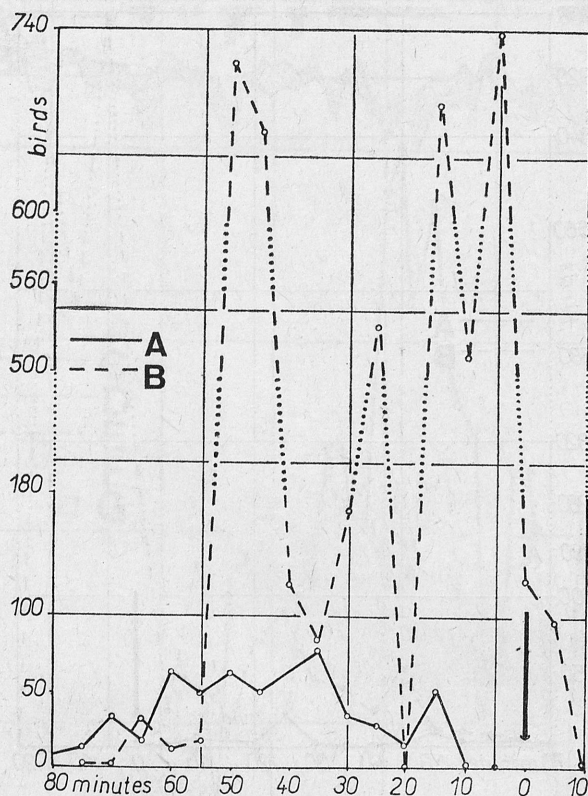


Fig. 5. Evening flights over observation point No. 3. Route III. For explanations see Fig. 3. Breeding birds: 23 Sept. 1975, 603 specimens; wintering birds: 14 Nov. 1975, 4440 specimens

For this purpose I chose two municipal parks (Krakowski Park — 5 ha and Jordan's Park — 21.8 ha) within the range of route I and a number of streets and I walked that way as often as possible between 8 and 9 o'clock in the morning from October till April. I made altogether more than 120 such inspections. The line of streets covers 2100 m, of which the initial 1400-metre part, parallel to the route of flights, extends in the east-west direction and the terminal part, 700 m long and square to the former, turns north. These streets run on the border of a district which has been developing for 30 years and now lies at a distance of 300-500 m from loosely built-up or quite open areas. The influence of climatic conditions, mainly that of frost and snow-cover, cannot be ignored here and nor can the influence of the approaching breeding season of the birds. The graph in Fig. 8 and Table V cumulatively summarize the observations and form a material basis for further considerations.

The relations prevailing in both parks have already been described (GRODZIŃSKI, 1971, 1976). According to several years' observations, considerably fewer birds stayed in Jordan's park in winter, where they were poorly fed by passers-by, than in Krakowski Park.

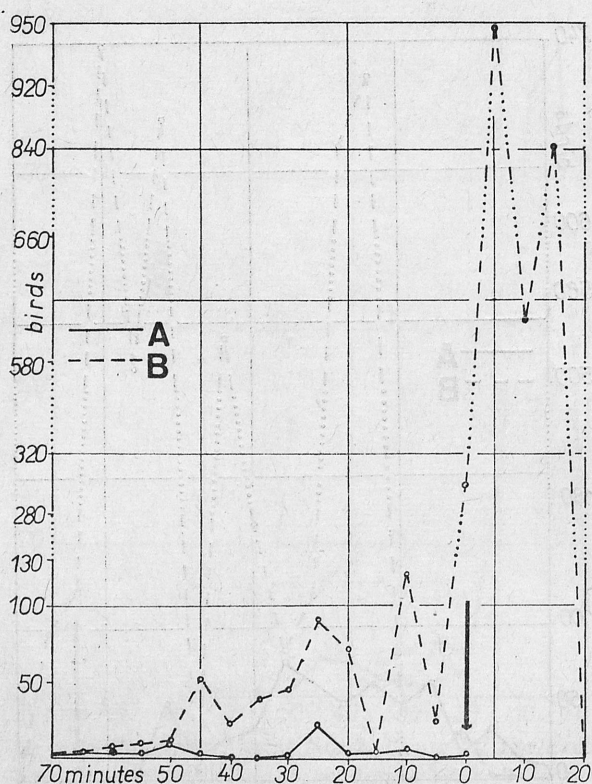


Fig. 6. Evening flights over observation point No. 4. Routes IV, IVN, and IV NW. For explanations see Fig. 3. Breeding birds: 27 Sept. 1975, 62 specimens; wintering birds: 13 Nov. 1975, 3187 specimens

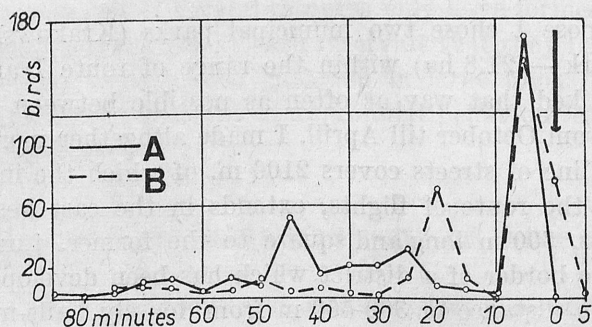


Fig. 7. Evening flights over observation point No. 5. Route V. For explanations see Fig. 3. Breeding birds: 25 Sept. 1975, 387 specimens; wintering birds: 9 Nov. 1975, 395 specimens

The curves representing the numbers of Rooks and Jackdaws in Krakowski Park and along the line of streets strikingly resemble each other. They begin at the zero point at nearly the same time and also converge at the end. The ascending slopes rise gently and in accordance with each other from October

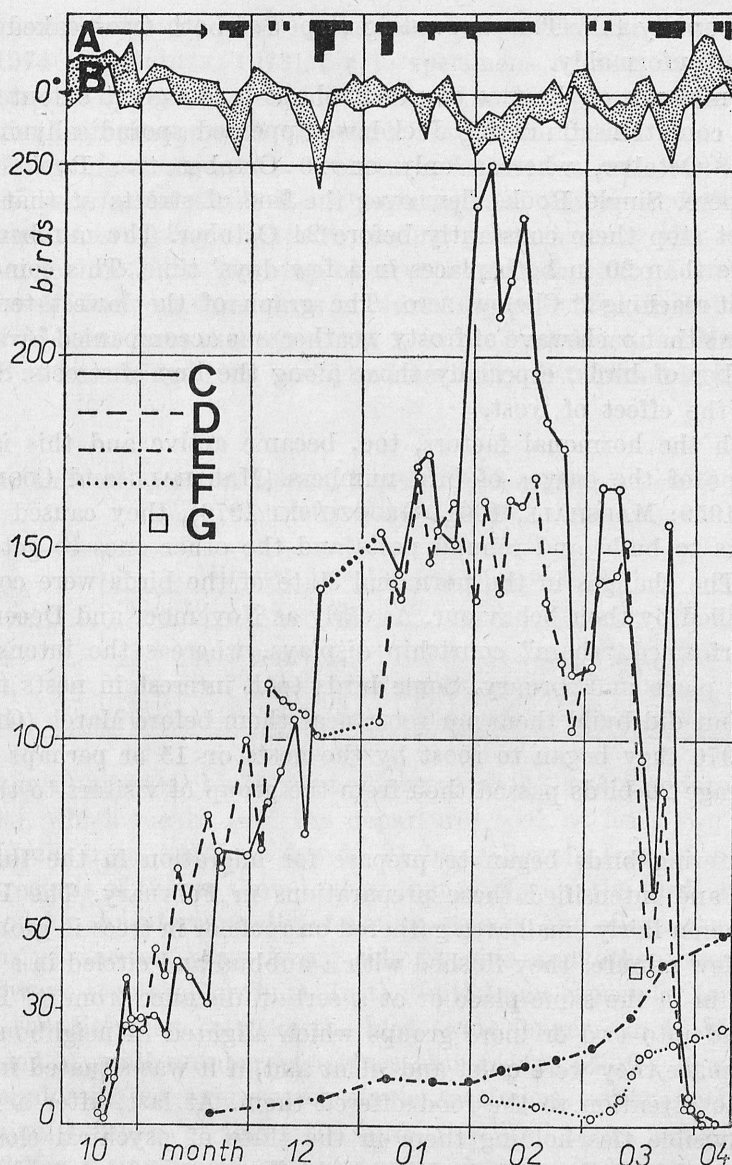


Fig. 8. Invasion of wintering Rooks and Jackdaws in Krakowski Park and in the built-up area along the course of streets, 2100 m long, in 1975/1976. Ordinates — number of birds, abscissae — months. A — days with snow cover, B — max. and min. temperatures of given day, C — line connecting points representing numbers of birds in Krakowski Park on particular days of observation, D — ditto for birds observed along the course of streets, E — numbers of Rooks connected with nests, F — number of nests of Rooks in Krakowski Park, G — date of departure of Rooks not breeding in the park

to mid-January. They reach the level of about 160 birds, which maintains with some fluctuations in Krakowski Park to the second half of February. On the other hand, the numbers noted along the streets rise rapidly in this

period and rapidly fall. The descending slopes of both two-peaked curves fall steeply and conformably.

The resemblance of the two curves in shape is to a great extent dependent on weather conditions. Foraging Jackdaws appeared sporadically in the park as early as 8 October, whereas only on 20 October two Rooks were seen to forage there. Single Rooks flew over the line of streets at that time, but they did not stop there constantly before 24 October. The number of Rooks rose to more than 20 in both places in a few days' time. This coincided with ground frost reaching 2° below zero. The graph of the lowest temperatures (Fig. 8) shows that each wave of frosty weather was accompanied by an increase in the number of birds, especially those along the line of streets. Snow-cover augmented the effect of frost.

In March the hormonal factors, too, became active and this is reflected by the shape of the curves of bird numbers (MARSHALL and COOMBS, 1957; LEHRMAN, 1959; MARSHALL, 1961, GRODZIŃSKI 1976), they caused some wintering Rooks to build and rebuild nests and the other ones to get ready for departure. The changes in the hormonal state of the birds were considerably earlier signalled by their behaviour. As early as November and December some of them performed "sham" courtship displays, whereas the intense displays proper took place in February. Some birds took interest in nests throughout the winter but did build them nor roost near them before March (GRODZIŃSKI, 1976). In 1976 they began to roost by the nests on 15 or perhaps 14 March. On the average 20 birds passed then from the group of visitors to that of residents.

The wintering birds began to prepare for migration in the third decade of January and intensified these preparations in February. The Rooks that fed together in a fairly small area gathered on roofs or in trees in groups of 20—80. After a few minutes they flushed with a hubbub and circled in a close flock to settle again in the same place or at a certain distance from it. They sometimes divided into two or more groups which alighted in neighbouring trees. In the new place they were quiet and silent and, if it was situated in the park, they paid no attention to the food offered them. At last, after a fairly long time the invisible ties holding them in the state of psychical closeness and tension released and the birds scattered chiefly in search of food. Jackdaws did not take part in such training departures, which I observed once in January, 8 times in February and twice in the first days of March. They occurred 6 times in the parks, 4 times over the roofs of houses and once over a busy street.

The first distinct fall in the number of Rooks feeding in Krakowski Park was noted on 15 March and that along the streets inspected not before 18 March. On this day the Rooks staying out of the nests in the park stopped coming to the food thrown for them systematically in the same place. Perhaps they belonged to a new group that had come from the west, whereas the wintering birds had just flown away. The number of non-nesting birds did not approach zero either in the park or along the examined streets before 26 March. The

departure of a large group of Rooks from Krakowski Park was observed on 11 March 1974 (GRÓDZIŃSKI 1976). Single specimens feeding in the park and in the streets still appeared in the first decade of April, however they were exclusively young specimens with the black base of the beak.

The foregoing changes, i. e. departures for the east and nest building, occur simultaneously in the whole Rook population of the town. In this connection the picture of everyday flights to feeding grounds along the constant routes must change, too. The morning observations from route I carried out west of Krakowski Park on three days of March are presented in Table IV.

It can be seen from this table that 1. in the first decade of March the flights were still at full swing (1262 birds) and normally distributed in time, 2. marked

Table IV

Numbers of birds taking part in morning flights to feeding grounds close to observation point No. 1 (Fig. 1) in 1976

| Date | Minutes from the beginning of flight | | | | | | | | | | Total of birds |
|----------|--------------------------------------|-----|-----|-----|-----|-----|-----|----|----|----|----------------|
| | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | |
| 7 March | 27 | 231 | 188 | 349 | 159 | 133 | 111 | 62 | 2 | — | 1262 |
| 13 March | 7 | 71 | 247 | 197 | 183 | 55 | 15 | — | — | — | 775 |
| 28 March | 10 | 19 | 16 | 21 | 15 | 12 | 3 | 7 | 7 | 6 | 116 |

falls in the number of birds were observed on 13 and 28 March (to 775 and 116 birds), which means that the departures took at least two weeks, and 3. on 28 March from hardly a few to 21 birds flew in five minutes' time. The detailed records of flights show that at first (7 March) the birds appeared in the field of vision uninterruptedly, forming strings and close groups of 20—50 specimens. Numerous pairs flying side by side and other ones more loosely arranged were seen among them. In the initial and especially terminal minutes of flight the distances between the birds were longer. On 13 March the birds still formed a small number of strings and groups of 10—20 each, but pairs visibly predominated over scarce single specimens in the field of vision. In the terminal minutes of flight the birds flew well apart from each other. At last on 28 March single specimens and rare pairs prevailed. Both the arrangement and the figures prove that the females already stayed in the nests, 21 of them probably in Krakowski Park, as this was the number of nests in it, and the males went foraging. In the final 10 minutes of observation I saw six birds already returning to the nests. Apparently they had foraged somewhere near and were returning with food for the incubating females.

The average numbers of Rooks and Jackdaws in the sections of the street line (Fig. 9), differing in their urban character, are illustrated in Table V. Daily counts were made from 8 to 9 a. m. The itinerary was greatly differentiated as regards its urban character: it included closely built-up streets, market places, squares, an orchard, pathways for pedestrians, a set of three high blocks

of flats, lower blocks of flats and, in addition, a church and some one-family houses. According to this state 7 sections (A—G) have been distinguished in the parallel branch of the itinerary and 3 (H—K) in the meridional one, square to the former. The numbers of birds were recorded always separately for each section. The rate and degree of the penetration of the large parks and the line of streets by birds were compared on the basis of the material collected. The attractiveness of these different sections of the course of streets to the birds

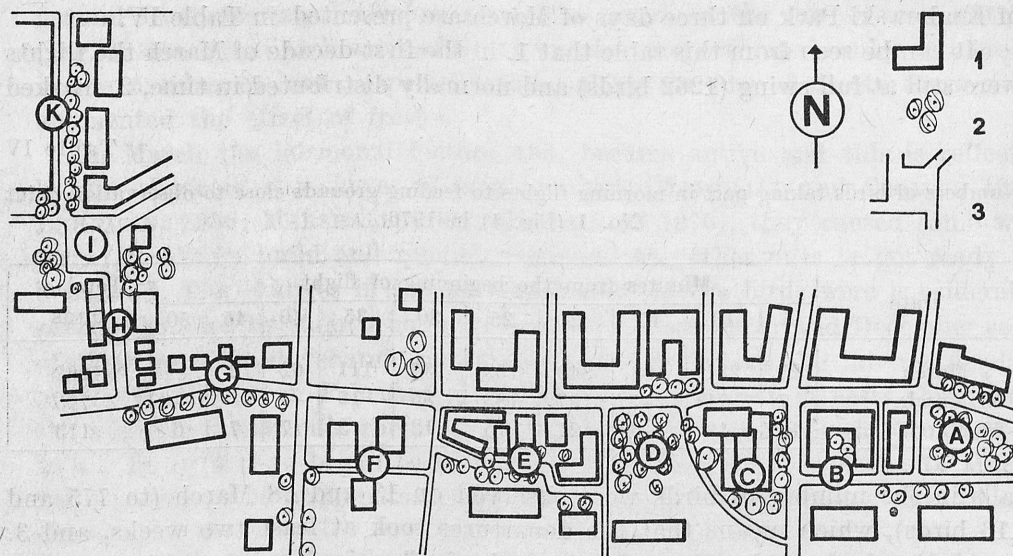


Fig. 9. The schematic map of the course of streets where Rooks and Jackdaws were counted in the winter of 1975/1976. 1 — streets and places, 2 — large buildings or groups of small buildings, 3 — trees (the number of marks does not indicate that of trees), A—K — different sections described in the text and mentioned in table V

was also observed. The columns of the table give the picture of each section during six months of observation, from October throughout March. The horizontal rows make it possible to evaluate the degree of interest the birds take in particular section of the course of streets in each month separately. This state is summarized in the last column, which gives the numbers of Rooks recorded there in each month and the mean daily numbers in particular months. These numbers are far from absolute accuracy, which is due to the difference between the size of the area being exploited by the birds and the considerably smaller area regularly inspected and, what is more, during only one hour daily. The error in calculation is partly eliminated by summing up the numbers of birds in a given section recorded in particular observations during a month. This approach brings out the monthly changes in the frequency of birds and in sections of streets in which they stay more frequently and this was just the actual purpose of observation.

Table V
Mean daily number of Rooks and Jackdaws in different sections of the course of streets in the winter of 1975/1976

| Number of observations in months | Sections of the course of streets discussed in the text | | | | | | | | | | | Number of birds from the whole course | |
|----------------------------------|---|------|------|------|------|-----|------|-----|-----|-----|--|---------------------------------------|------------|
| | A | B | C | D | E | F | G | H | I | K | | Monthly | Daily mean |
| October 10 | 1.8 | 2.2 | 2.5 | 2.8 | 1.8 | 2.0 | 0.4 | 3.6 | 0.5 | 0.5 | | 179 | 17.9 |
| November 17 | 4.0 | 4.0 | 9.9 | 6.9 | 1.7 | 3.1 | 2.0 | 3.0 | 1.8 | 1.6 | | 543 | 36.3 |
| December 14 | 9.2 | 7.6 | 25.7 | 19.3 | 9.4 | 3.2 | 5.9 | 7.5 | 6.9 | 3.0 | | 1373 | 98.0 |
| January 23 | 25.5 | 13.0 | 59.9 | 36.2 | 13.9 | 5.1 | 7.4 | 7.8 | 3.3 | 7.0 | | 3752 | 170.0 |
| February 24 | 20.3 | 16.5 | 50.5 | 52.0 | 9.0 | 7.2 | 11.5 | 9.0 | 8.9 | 4.7 | | 4180 | 190.0 |
| March 26 | 14.3 | 7.1 | 28.1 | 27.1 | 5.4 | 2.3 | 6.5 | 5.8 | 4.9 | 2.5 | | 2610 | 104.4 |
| Mean from the section | 12.5 | 8.4 | 29.4 | 24.0 | 6.8 | 3.8 | 5.6 | 6.1 | 4.3 | 3.2 | | — | — |

The number of birds observed all along the course of streets was the largest in February, on the average 190 birds each day, somewhat smaller in January (170 birds) and still smaller in March (104.4). In the remaining months the mean daily frequency did not exceed 100 specimens. Fig. 8 shows the peaks of the actual daily numbers, which reached 250 birds on the boundary between January and February.

The numbers of Rooks in particular sections of the course of streets differed still more from each other. Sections C and D were specially preferred. Their averages overtopped the averages from the remaining sections in all the months, being about 50 birds per day in January and February. These sections have several similar characteristics making them attractive for Rooks. Both have groups of big trees and large lawns and in both people give food, especially to pigeons. These sections pass into each other without any visible boundary, section D being a small square with sparse trees and a tennis court. On the other hand, section C includes a church, a hospital and a close group of big trees, and its eastern border is formed by a busy broad street with a zone of green and some young trees. Here the Rooks used to have some dozen observation posts in trees, from where they came flying to the food offered. Section C was richer in food, chiefly because of the presence of dustbins with hospital refuse. The mean daily frequency for the whole season was 29.4 birds in section C and 24 in D.

The daily means for sections F, H, I and K never exceeded 10 birds. Section F is a large grass-plot surrounding three high blocks of flats. There being no trees here, the Rooks had no observation posts at which they could have stayed on the look-out for food. They came here only when someone was giving food to pigeons. In addition, the lack of dustbins for kitchen garbage caused that only on snowless days a few Rooks scoured the lawns. As a result, this section was visited on the average by only 3.8 birds throughout the period of observations. Sections H, I and K were characterized by very irregular feeding, but they were convenient places with high observation posts from which the Rooks could make sallies to the adjacent courtyards and gardens invisible for the investigator.

Section E is somewhat more favourable to Rooks. Being a convenient passage only for pedestrians between blocks of flats and a long school building, it crosses a narrow grass-plot. On the south it is bordered by a row of medium-sized trees. A small number of Rooks sat in chosen trees and waited for people to begin feeding pigeons, or they searched the dustbins. The mean number of Rooks in the winter was only 6.8, reaching 13.9 in January.

The market-square which constitutes section A is bordered by houses on two sides, while on the third side it merges into a green with young shrubs and several big trees. As a matter of fact, the birds were not fed here, instead they found remains of different foodstuffs sold in this square. The mean daily number reached 20—25 Rooks in January and February.

The distribution of Rooks in the area under study is dependent, in addition to climatic conditions (frost and snow), upon several other factors; of these, the accessibility of food and the presence of trees as coigns of vantage come in first. The trees must be suitably high and branchy. Slim black poplars are no fit for this purpose and Rooks alight in them exceptionally. A screen from winds, to which they are very sensitive, is also important.

In January and February the Rooks gathered in the areas adjacent to the course of streets in markedly larger numbers than they did in Krakowski Park (Fig. 8). As the weather conditions were the same and the amount of accessible food had not increased here, the cause must have lain elsewhere. Krakowski Park is surrounded by a wide zone of buildings of medium size, standing close to each other, in which the number of constant visitors is limited. Frost brought the birds together to the park as early as mid-January. The course of streets extends in a more loosely built-up zone, creating better chances for the birds to find food in gardens, orchards and lawns. Thus, in this period the Rooks left the much larger area to gather together chiefly in the most favourable sections (A, B and D).

The invasion of Rooks was accompanied by that of Jackdaws, but this last was markedly less numerous and somewhat shifted in time. More than ten Jackdaws foraged in the courtyards of houses west of Krakowski Park everyday throughout September. They availed themselves of the food offered together with pigeons, numerous here, and searched the dustbins. However, they did not appear along the streets inspected. Rooks and Jackdaws gathered in Krakowski Park late in the afternoon but they left for their roosts in the Planty before sunset.

The first two feeding Jackdaws appeared in Krakowski Park in the morning as early as 8 October and the Rooks did not feed here before 20 October. Starting from this day, the number of Rooks feeding in the park increased very quickly, while the number of Jackdaws kept here at the level of 2—6 birds daily. In the frosty period of January and February their number rose to 4—10 birds on some days. At the end of March and in April, when the non-breeding Rooks had disappeared, several Jackdaws still visited the park. They were busy feeding but, above all, collected material for nests.

Along the streets inspected the first two Jackdaws were observed on 24 October and from this day onwards they were seen nearly everyday, varying in number from 1 to 7 and exceptionally more. They were still present in the first half of April, occupying themselves with collecting nest material. When no Rooks appeared here, the Jackdaws showed a preference of sections A, C, D, and G.

In February 1976 the average number of Jackdaws in relation to that of Rooks was about 2.7% in Krakowski Park and 2.1% along the streets inspected. Earlier, however, in 1969, the Jackdaws formed up to 5% of the number of Rooks feeding here (GRODZIŃSKI, 1971).

VI. COMMENTS ON RESULTS

Nest building time

When the breeding season comes, a certain number of pairs of Rooks separate from the flock of Rooks and Jackdaws wintering in Cracow and begin to build nests and roost by them. The other birds fly away to their breeding sites in the east about mid-March. At the same time the birds returning from the western winter quarters join the rookeries which are just developing here. The Jackdaws, however, still fly to their feeding-grounds and back to roosts in flocks of various size for a long time. It is not before the end of March that their pairs occupy tree-holes and suitable recesses in buildings for nests.

The lengthening time of daylight releases the phenomena of breeding and then in our case the building of nests and migration to breeding sites (ROWAN, 1931; LOFTS and MURTON, 1968; LOFTS, 1976; MANNING, 1976). The question arises why two related bird species, living together in the same habitat, behave so differently. The differences between them in the situation and structure of nests and in material used to build nests have been emphasized in the section on nesting. Rooks acquire material making use of the strength of their powerful beaks and Jackdaws, having a weaker beak, rather gather suitable material that lies on the ground. The differences in the structure of their bodies are illustrated by the beak:tarsometatarsus length ratio. The beak of the Rooks, 5.5 cm long, somewhat exceeds the tarsometatarsus in length, whereas the 3.5-centimetre-long beak of the Jackdaws is markedly shorter than its tarsometatarsus (SOKOŁOWSKI, 1958). Hence, in March, when the building material lies frozen in the top layer of earth or covered by a continuous snow layer, Jackdaws cannot build their nests.

Jackdaws lived in the territory of Central Europe in the Middle and Upper Pleistocene, as proxed by the discovery of fossil remains of these birds at two localities in southern Poland (BOCHEŃSKI, 1974, in prep.) and at 17 localities in south-eastern France (MAURER-CHAUVIRÉ, 1975). Some of these remains come from the Eemian interglacial, with a considerably warmer climate (mean July temperature — $+20^{\circ}\text{C}$, after BOCHEŃSKI) than the climate of our time ($16-19^{\circ}\text{C}$). In that period Jackdaws could nest simultaneously with Rooks, early in the spring. During the spreading of the last, Baltic, glaciation (Würm), when the forests disappeared temporarily, spring groundfrost made it difficult for Jackdaws to collect building material from the ground. Then, natural selection began to act and all the specimens with the genetically conditioned earlier commencement of the cycle were removed from and those with the late cycle admitted to breeding. Only the Jackdaws whose internal biological clock was better adapted to the new climatic conditions have survived. Now the period of the increasing length of daytime or photoperiodism actuates Jackdaws' internal biological clock, which dates from those times and, compared with that of Rooks, is retarded by nearly a month.

Rallies at roosting site

In Cracow the roosting site of the breeding birds is situated in the Planty, in a basin-shaped depression well sheltered from winds (Fig. 2). The birds are not deterred by the heavy traffic of cars and trams at the adjoining cross-roads nor by the glaring light advertisements. However, an unexpected loud sound, e. g. a shot of a cork pistol, makes them take wing after a while. They roost here from April till October. Rallies for roosting proceed in a different way in different months and the composition of the roosting groups changes as well.

Several moments are worth emphasizing in these rallies: 1. At the beginning the birds gather at the roosting site individually and noiselessly long before sunset. 2. When the pre-roosting sites have come to be, the birds from the whole area of Cracow gather in them, not excluding those which have already spent the nights at the roosting site since May and June. 3. The birds move from the pre-roosting site to the roost in several waves after sunset. 4. They alight here after circling over the trees with a loud hubbub for a fairly long time. 5. The change in the pattern of flights is slow and gradual.

Less detailed observations suggest that the rallies have been proceeding similarly since 1969. It may therefore be assumed that in addition to the suitability of the place, the memory of older specimens is decisive as regards roosts and their pattern. The crucial role in the above-mentioned changes is played by the prerooting sites, which arise later than and independently of the roosting site.

The pre-roosting sites lie in the northern section of the loop of the Planty (Fig. 2). In the summer the Rooks, probably those nesting in the Planty, started to gather and roost at them. In 1975 there were 114 nests left in the Planty at the end of April and supposedly the birds bred normally in them. Considerably more nests had been removed from trees in the course of an action to keep the walks clean, chiefly in March. In June the inhabitants of the remaining nests, 580 in number (calculated on the basis of OWEN'S, 1959, index) returned towards them for the night from the feeding-grounds. Several tens of Rooks joined the Jackdaws roosting in the region of Sienna St. Most of the Rooks began to flock at the pre-roosting sites, which were at an initial stage. The Jackdaws also gathered together with them, at first in small numbers. The birds nesting in the rookeries situated outside the Planty and flying over these two sites began to stop here on the principle of "passive cooperation" in gradually increasing numbers. Finally, all of them adopted the system based on the here situated pre-roosting sites. The time of rallies was more and more lengthened, because the birds came flying from different directions and at different times. Moreover, having gathered together, the birds took some dozen minutes to quieten and decide on flight. They eventually started on a mass-flight to their roosts after sunset (Table I).

Both Jackdaws and Rooks alight easily and unfallibly on branches in such dark that people cannot perceive them. They owe this to their good sight, for

it has been demonstrated in experiments with feeding that they can distinguish food offered to them in the light reduced to several luxes (DĄBROWSKA, 1975).

The wintering birds roost in small groves at Łęg and Mogiła. The occupation of this area for roosts is connected with the beginning of autumnal migrations of both the breeding and those coming from the east. The sheltered situation of the roosting trees and, no doubt, the reminiscences of the older birds have a decisive influence on the settling of the first groups here. The next migrating groups also incline to "passive cooperation" and in consequence soon thousands of birds roost here.

Routes of feeding ground-roost flights

There are two roosting sites in Cracow, one of the breeding birds in the centre of the town and the other of the wintering birds close to its south-eastern outskirts, the distance between them being 8.4 km (Fig. 2). Such a distribution of the destination of their flights is decisive of the length of the routes and partly also of their direction. Since the initial places of rallies for most routes are unknown, the length of the routes can be determined only over the area of the town where the length of the flight routes of the breeding birds ranges from 2.1 to 2.8 km. On the other hand, the routes of the wintering birds are markedly longer, their length varying between 6 and 10 km. The flights by the three longest routes drag on until 5—20 minutes after sunset.

Observations (Fig. 3—7) started about 80 minutes before sunset show that in the first 30—40 minutes only few birds flew over each observation point with the exception of point 3. In the following minutes their number increased considerably, because the birds flew grouped in flocks varying in size. The former may have stopped on the way and fed. The latter flew direct to the roost. The breeding birds reached the pre-roosting site an hour before sunset, a few did not arrive before the phase of the subsidence of voices and flights from tree to tree. At any rate, at the pre-roosting site groups of birds from different routes mingled in accidental order dependent on the time of their flocking and starting on flight. The rallies at the two pre-roosting sites did not conclude at the same time, in the western site they lasted a few days longer than at the main eastern site. Some undetermined modifying factors bring about these differences in behaviour between the two groups of birds living as a rule under identical conditions.

The wintering birds begin to gather together for the roost at Łęg and Mogiła long before sunset, continually arriving groups settle in various places, in meadows, cultivated fields and several groups of trees, distributed over an oval area, 2 km in long axis. These places might be termed pre-roosting sites. Frequent flights from place to place last till sunset. Some birds do not appear here before the noisy period when the flock circles over the roosting trees 10—30 minutes after sunset. Finally, the birds become quiet settling slowly for roosting.

Winter invasion of built-up area

In mid-winter Rooks and less numerous Jackdaws occur at unequal densities all over the area of Cracow. They can be encountered in all plots of lawn, parks, gardens, avenues, squares, courtyards and refuse heaps. Sitting high in trees, on fences or roofs, they are on the look-out for food, or they seek it actively. The amount of available food determines the density of birds in a given place. The invasion of towns is chiefly induced by two weather factors: frost and snow.

The wintering flock of Rooks and Jackdaws was formed in the groves of Łęg and Mogiła from mid-October 1975 to reach a total of more than 9000 specimens (Table 3). It may have been still higher, as the route of flights from the south via Płaszów was not watched adequately. At first the birds fed in suburban fields and meadows of wide range, measured in kilometres, as has been stated for western suburban areas.

The beginnings of invasion of built-up areas by wintering birds do not fall before 20 October, i. e. the day when the first Rooks fed in Krakowski Park, which a few days earlier was transitorily visited by Jackdaws. In 1970 a flock of Rooks began to forage in "the Common" (Błonia) from mid-October and single specimens appeared in the Planty in the third decade of October (KMIETOWICZ, 1972).

However, from the end of breeding of both bird species to the beginning of invasion, Jackdaws were seen continually in built-up areas. They appeared on the roofs and in the courtyards of houses west of Krakowski Park as late as August and September. The same situation, as regards Jackdaws, recurred in 1976, chiefly in the morning and towards the evening, whereas single Rooks and even Magpies occurred here rarely. Sporadic observations show that small numbers of Jackdaws feed also in the Planty and in the gardens of the Clinical Hospitals. Nevertheless, a vast majority of birds do not visit the built-up areas in these months.

The Rooks that in winter forage among the building at the outskirts of the town clearly show preference for certain small units, like gardens, little squares and large courtyards. These must provide good observation posts, e. g. large trees, TV aerials on roofs and chimney-post, where they wait for food. Food is decisive of the attractiveness of these places. Most frequently the birds find it in receptacles for litter and garbage. Market places, courtyards of hospitals and restaurants also play an important role. Many people living there feed Pigeons and Doves; Jackdaws and Rooks avail themselves of these opportunities. Passers-by bring much bread, potatoes, grout and other food remains to some of the parks. As a result, considerably more Rooks gather together in Krakowski Park than in four times as large Jordan's Park, where feeding is done on a very small scale. A similar situation occurred in the Planty in 1970/1971. Here half the Planty population aggregated in one section, while the number of birds in any other section amounted to one-seventh of the total (KMIETOWICZ, 1972). Strikingly many Rooks gathered in "the Common", their number

being always larger than in Jordan's Park, even though there was practically no feeding of birds by people and there are hardly any trees here so that the Rooks used to stay mostly on the ground (KMIETOWICZ, 1972).

If the aim of these invasions is the acquisition of food, they are caused by frost and snow, which make it hard for the birds to feed in the fields. This has been emphasized repeatedly (PINOWSKI, 1959; GRODZIŃSKI 1971, 1976). The seemingly atypical behaviour of Rooks during frosty spell in January and February 1976 (Fig. 8) should be elucidated here. At that time the number of Rooks in Krakowski Park fluctuated around 160, whereas along the course of inspected streets it rose to more than 200. This was so because some additional birds appeared in the streets, coming from the neighbouring gardens and courtyards inaccessible to the observer, where they had hitherto been feeding. In the third decade of March (20—24) a sudden recurrence of winter weather caused a gathering of more than 150 birds, which fed along the streets, while in the park the number of Rooks staying by the nests increased only by 40 birds. These were "visitors", more numerous in areas at the back of the streets inspected.

In the second half of March the number of Rooks decreased gradually, and they flew away in groups to the east. Only single young Rooks stayed foraged for some time, but they, too, disappeared in the first decade of April. On the other hand, the Jackdaws fed in the parks, squares and along the streets under study till mid-April. Later, they also collected building material for nests in these places, although single specimens kept appearing as feeding birds all over the study area in the breeding season.

The breeding Rooks only live and roost in the built-up area, whereas they fly out of town in search of food. On the contrary, the wintering Rooks come in large numbers to the built-up areas, where they seek food, overcoming their shyness of people. The breeding Jackdaws forage out of town, too, but some of them keep feeding among town houses. In winter, they often make use of available food together with Rooks. Then they are shyer of people than are the Rooks, with which they are associated by common roosts and similar routes of flights to and from the feeding-grounds.

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STRESZCZENIE

Roczny cykl życiowy gawronów i kawek związanych z Krakowem rozpada się na dwa okresy — rozród i zimowanie. Pod koniec pierwszego okresu naliczono podczas przelotów na nocleg do centrum miasta ponad 3800 osobników. Liczba zimujących i żerujących w mieście ptaków przekracza 9100 osobników (tabela III). Wśród nich znajduje się nieokreślona bliżej liczba ptaków lęgowych, a większość stanowią przybysze ze wschodu. Ptaki z tej grupy nocowały w laskach na południowo-wschodnim obrzeżu miasta, w odległości 8,4 km od noclegów letnich (ryc. 1).

W miejscach noclegowych rosną prawie wyłącznie drzewa liściaste, a sfalowania terenu osłaniają je od wiatrów. Stwierdzono, że już pod koniec kwietnia samce kawek lęgowych nocują na Plantach, później dołączają się do nich nieznaczne rodziny gawronów. Z wolna i stopniowo rozwijają się dwa miejsca przednoclegowe, skąd ptaki lecą gromadnie na właściwy nocleg. W październiku (12) ptaki lęgowe opuściły Planty i przenieśli się do zimowych noclegowisk (ryc. 2: R, PR I, II).

Przeloty na nocleg ptaków zarówno lęgowych, jak i zimujących, kontrolowane w pięciu punktach miasta, charakteryzują następujące dane: Przeloty zaczynają się co najmniej na godzinę przed zachodem słońca. W pierwszej połowie tego czasu ciągną w zasadzie pojedyncze osobniki lub małe grupki, później liczne stada różnej wielkości. W miejscu zbiórek stada lecące różnymi trasami lądują w czasowej kolejności przybycia i mieszają się ze sobą. Ciągi kończą się koło zachodu słońca, a na niektórych trasach zimowych przeciągają się poza ten termin (ryc. 3—7).

Gawrony budują gniazda otwarte w postaci solidnych i trwałych czasz, kawki ukryte w zakamarkach budynków lub dziuplach w sposób raczej niedbały. Gawrony, ptaki krepie i silne, łamią z łatwością swoim mocnym dziobem gałęzie i wyrwywają pęki trawy z korzeniami i ziemią. Natomiast kawki lżejsze i smukłe, obdarzone słabszym dziobem, raczej zbierają nim materiał budulcowy z ziemi. Mrozy wczesnowiosenne wiążą ten materiał w grudzie, a śnieg przykrywa go całkowicie. W tym można dopatrywać się przyczyny, że kawki rozpoczynają budowę gniazd znacznie później niż gawrony.

Zespół zimujących ptaków żeruje początkowo na podmiejskich polach i łąkach. Pierwsze przymrozki w trzeciej dekadzie października powodują, że ptaki zaczynają zapuszczać się w zabudowane tereny miasta w liczbie szybko rosnącej. Kontrola inwazji w dwu większych parkach i przeszło dwukilometrowym ciągu ulic daje wgląd w przebieg i mechanizm tego zjawiska (ryc. 8 i 9, tabela V). Stopień zagęszczenia ptaków, przede wszystkim gawronów, w terenach zabudowanych odznacza się wielką różnorodnością. Ptaki unikają ciasnych, zagubionych wśród ścian domów podwórzy. Odwiedzają natomiast wszystkie ogrody, zadrzewione zieleńce, place targowe, obszerne podwórza, o ile znajduje się tam dostępny dla nich pokarm i dogodne punkty obserwacyjne w postaci drzew, dachów, kominów, anten, z których bacznie śledzą, co dzieje się w okolicy. Pokarm, początkowo naturalny, składa się z owadów, mięczaków i dżdżownic ukrytych w trawie lub w opadłych liściach. W ciągu zimy stale dostępne są odpadki kuchenne w pojemnikach na śmieci i pokarm podawany przez mieszkańców. W dziesięciu odcinkach ciągu ulic o urozmaiconym typie urbanistycznym obecność żerujących ptaków wahała się w porannych godzinach w lutym, miesiącu najtrudniejszym dla nich, od 4,7—52,0 osobników dziennie (tabela V). Obok gawronów żerowały stale kawki, ale stanowiły tylko 2,1—2,7% zespołów. Natomiast w drugiej połowie marca, kiedy gawrony zostały tylko przy gniazdach, kawki dalej żerowały tutaj i zbierały materiał na gniazda aż do połowy kwietnia.

Gawrony i kawki reagują zdecydowanie na cykliczne zmiany w nasileniu światła, które zachodzą w ciągu roku, a także w ciągu jednego dnia (fotoperiodyzm). Do pierwszej grupy należą migracje wiosenne i jesienne oraz rozród, do drugiej przeloty między miejscami noclegowymi a żerowiskiem. Część naszych gawronów przechodzi dwa razy okres toków, poronny w jesieni i właściwy na wiosnę. Cykl rozrodu kawek zaczyna się tylko raz na wiosnę, ale w terminie przesuniętym blisko o miesiąc w porównaniu z gawronami. Anomalie klimatyczne, jako czynnik modyfikujący fotoperiodyzm, mogą przyspieszyć lub opóźnić ten proces, a duży śnieg może nawet przerwać na kilka dni budowę gniazd gawronich.

Gawrony łączą się doraźnie w grupy na zasadzie "passive cooperation" np. przy żerowaniu, podobnie kawki przy zbieraniu budulca na gniazdo. Ptaki tworzą z łatwością stada mieszane, liczące setki i tysiące sztuk, szczególnie w okresie migracji lub podczas zbiórek przednoclegowych. W tym drugim przypadku ptaki muszą się uspokoić i wyciszyć, zanim zdecydują się na odlot do

miejsca noclegowego. Decyzja nie dojrzewa u wszystkich jednocześnie i w jednakowym stopniu. Jeżeli nawet zerwie się grupka ptaków już zdecydowanych, większość nie przyłącza się do nich. Dopiero sygnał odlotu którejś kolejnej pociąga resztę za sobą (tabela I). Jeszcze silniejsze rozbieżności nastroju zdradzały ptaki opuszczające Planty dnia 12. 10. Jedne ptaki leciały wprost do zimowego noclegowiska, inne krążyły długo nad dotychczasowym, inne nawet siadały tam na kilka minut. Ostatecznie jednak wszystkie porzuciły Planty (tabela II). Ptaki nie kierowały się zatem automatycznie zachowaniem osobników zdecydowanych do odlotu. Wahały się, ociągały przez kilkanaście minut, wreszcie uległy ich przykładowi. Stado kawek i gawronów nie jest wobec tego zwartym i w pełni zdyscyplinowanym zespołem, czym różni się zasadniczo od stada szpaków.

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