ACTA ORNITHOLOGICA
Vol. 24 (1988) No. 1

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Synurbization of the mallard *Anas platyrhynchos* in Warsaw

ENGEL J., KELLER M., LESZKOWICZ J., ZAWADZKI J. 1988. Synurbization of the mallard *Anas platyrhynchos* in Warsaw. Acta Orn. **24**: 9–28.

In the period 1979–85 studies of the numbers and breeding of the mallard were carried out in areas of their occurrence in Warsaw. The lowest level of numbers was recorded during the breeding season. The number of breeding pairs in the whole city was estimated at *c.* 100. Nearly all the nests found in Łazienkowski and Ujazdowski parks had been built in trees – in trunk holes and baskets. No phenological or clutch size differences were found in comparison to countryside areas. Predators pressure on nests with eggs was insignificant, but duckling mortality was high (70–80%). In June and July there were 350–450 moulting drakes in the parks. In late summer and in autumn the numbers of mallards increased, their maximum level then coming up to 1–2 thousand individuals. The largest number of mallards were found in Warsaw in winter – 2500 to 6000, 1200 up to 3200 thereof in urban areas. Falling temperatures caused an increase in numbers. Bird safety was the most important factor making the city attractive for the mallards throughout the year and causing their synurbization.

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Процесс синурбанизации обыкновенной кряквы *Anas platyrhynchos* в Варшаве

В 1979-1985 годах провели исследования по численности и размножению обыкновенной кряквы в важнейших местонахождениях ее в Варшаве. Самая низкая численность наблюдалась в гнездовой период. Количество гнездящихся пар на территории Варшавы всего города определили на около 100. Почти все гнезда в парке Лазенки и в Уяздовском парке утки заложили в дуплах либо специальных гнездовых корзинах. Не отмечалось различий в фенологии и в величине кладок по сравнению с внегородскими территоруями. Пресс хищников на гнезда с яйцами был незначительный. Смертность птенцов была очень высокая (70-80%). В июне и в июле в парках пребывало 350-450 линяющих самцов. Поздним летом и осенью численность кряквы возрастала, максимум в этот период составлял 1-2 тыс. особей. Больше всего уток пребывало в Варшаве зимой — от 2500 до 6000, причем 1200-3200 в центре города. Падение температуры сопровождалось ростом численности. Безопасность птиц была решающим фактором, привлекающим обыкновенную кряквy в город на протяжении всего года, и способствующим процессу синурбизации этого вида.

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INTRODUCTION

The process of animal synurbization, meaning adaptation to the conditions of the urban environment and changes within the urban populations, has been studied in detail for a few avian and mammalian species (*e.g.* HEYDER 1955, TOMIAŁOJĆ 1976, 1980, ANDRZEJEWSKI *et al.* 1978). The mallard, as one of the species that easily adapt themselves to the conditions of the urban environment, has also been the object of such studies (RAITASUO 1964, HANSSON 1966, FIGLEY and van DRUFF 1982 and others). The penetration of this duck species into towns in the various parts of the continent of Europe was not simultaneous. In Great Britain it began at the beginning of the 20th century (CRAMP and TEAGLE 1952, CRAMP and TOMLINS 1966), in Finland in the thirties of this century (RAITASUO 1964), and in the north-western part of the Soviet Union in the sixties (CHRABRYJ 1979).

In the literature dealing with the birds of Warsaw (LUNIAK *et al.* 1964, LUNIAK 1981) the fifties have been adopted as the beginning of the synurbization of the mallard. In the middle fifties the size of the breeding population in the Łazienkowski and Skaryszewski parks jointly was as small as over a dozen pairs, whereas during migrations and wintering their number in either of this areas was of the range of several dozen individuals (PIELOWSKI 1957, PAWŁOWSKI 1963). In the early 1960s the number of breeding pairs in the city was estimated at slightly over 40 (according to the data in the paper by LUNIAK *et al.* 1964), and the number of wintering individuals at 300–500. In later years, the mallards staying in the city gradually grew in numbers — in the early seventies over 300 individuals wintered in the Łazienkowski Park alone, and in the Ujazdowski Park and Zoological Garden 100–200 individuals in each (LUNIAK 1981).

Apart from the above data on abundance changes there has been no other description of the progressing synurbization process of the mallard in Warsaw. For this reason, it was decided that by determining some of its parameters even at present it may be possible to answer the question concerning the mechanisms governing it. The aim of this study was to determine the nature and the causes of urban area utilization by the mallard in Warsaw.

MATERIAL AND METHODS

The study was carried out in the years 1979–85 by the following methods:

1) Determination of population dynamics over the yearly cycle

Determination of population dynamics was based on weekly counts carried out from the beginning of April 1979 until the end of March 1983. Following a preliminary area identification five study plots were selected which represented the main areas of occurrence of mallards in Warsaw. As a rule,

counting in all the plots was done on one day, sometimes on two consecutive days. From the end of September till the beginning of July the individuals censused were divided into sex groups. The dynamics of numbers in all the study plots will hereafter be treated jointly as the dynamics of numbers in the whole city.

2) Estimation of the number of mallards wintering in Warsaw

In the wintering seasons 1980/81 to 1984/85 during the period from November to March mallards were counted in most of the potential areas of their occurrence in the city (Fig. 1). Since the urban stretches of the two rivers — the Vistula and the Wilanówka were similar to those outside the city, both rivers were included in the category of suburban terrains. All other sites were included in the urban-area category.

3) Breeding study

Data were gathered during four consecutive breeding seasons 1979–82. Breeding pairs were counted in the study plots every week. Apart from this, the areas were searched for nests. Nest checking was limited to two plots where mallards nested most abundantly. They were the Ujazdowski and the Łazienkowski parks. To increase the number of checked clutches, in March 1980 19 baskets were hung on trees, and another 10 in the March of 1981. All the nests found were checked about every 10 days. The fate of 81 clutches was followed including 47 clutches in baskets. During nest checking the time of laying was determined by back-dating — on the basis of the number of eggs in incomplete clutches and the stage of development of the embryo (Majewski 1980) in incubated eggs. The size of each clutch and its final fate were also recorded. A clutch was considered successful if at least 1 young was fledged from it. To determine the survival rate of young, the size and age were recorded of every brood observed, on the basis of Gollop and Marshall quide (1954). The number and age of young of a total of 330 broods were determined (part of the observations concerned the same broods).

STUDY AREA

All study plots were situated in central districts of Warsaw (Fig. 1). They differed, however, by the number of people visiting them, dog penetration, number of potential nesting sites, number and size of water bodies, ice-free surface area in winter, as well as by the amount of food supplied. The public fed mallards in winter, but rarely in spring and summer. In none of the plots were predators dangerous to adult mallards found to be present.

In the Łazienkowski Park (Fig. 1: 1), 86 ha in area, there were 4 ponds of a joint surface area of about 5 ha, interconnected by canals of a total length of about 800 m. In winter, there were always ice-free areas of the size of several dozen m^2 on the ponds. There were very numerous old trees with holes in

their trunks, providing good conditions for nest sites. The low vegetation present there created good conditions for ground nesting. The park was visited by large numbers of people, especially during week-ends. Bringing-in dogs was banned.

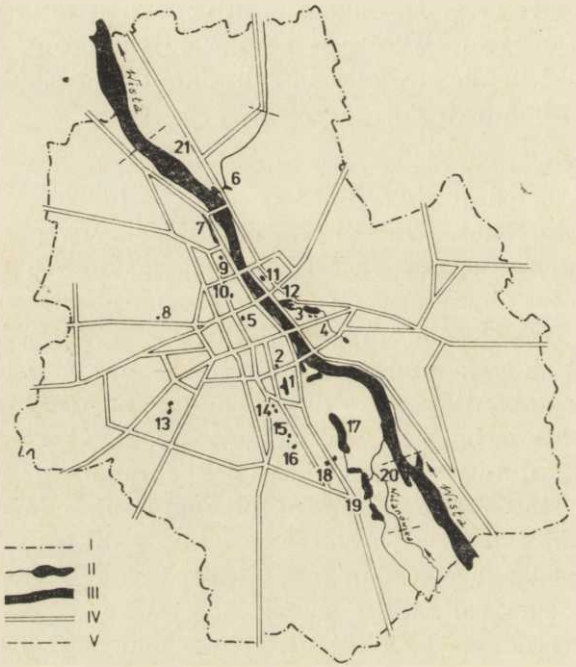

Fig. 1. Areas in Warsaw where mallards were counted

Areas 1–5 – permanent areas of weekly counts, other areas – areas of monthly counts in the period November–March. Area designations: 1 – Łazienkowski Park, 2 – Ujazdowski Park, 3 – Skaryszewski Park, 4 – Gocławski Canal, 5 – Saski Garden, 6 – Żerański Canal, 7 – Kępa Potocka Park, 8 – Moczydło Park, 9 – Hibner's Park, 10 – Krasiński Garden, 11 – Zoological Garden, 12 – Praski Port, 13 – Szczęśliwicki Park, 14 – Morskie Oko Park, 15 – Arkadia Park, 16 – Mokotowskie Forts, 17 – Lake Czerniakowskie, 18 – Forts on Sadyba, 19 – ponds at Wilanów, 20 – the Wilanówka river, 21 – the Vistula (urban stretch), I – city boundaries, II – ponds, lakes, III – canals, rivers, IV – main streets, V – boundaries urban stretches of rivers (covered by census)

Ryc. 1. Miejsca liczeń krzyżówki w Warszawie

Powierzchnie 1–5 – stałe powierzchnie liczeń cotygodniowych, powierzchnie pozostałe – tereny liczeń comiesięcznych w okresie XI–III Oznaczenia powierzchni: 1 – Park Łazienkowski, 2 – Park Ujazdowski, 3 – Park Skaryszewski, 4 – Kanał Gocławski, 5 – Ogród Saski, 6 – Kanał Żerański, 7 – Park Kępa Potocka, 8 – Park Moczydło, 9 – Park Hibnera, 10 – Ogród Krasińskich, 11 – Ogród Zoologiczny, 12 – Port Praski, 13 – Park Szczęśliwicki, 14 – Park Morskie Oko, 15 – Park Arkadia, 16 – Forty Mokotowskie, 17 – Jezioro Czerniakowskie, 18 – Forty na Sadybie, 19 – stawy w Wilanowie, 20 – Wilanówka, 21 – Wisła (odcinek miejski), I – granice miasta, II – stawy, jeziora, III – kanały, rzeki, IV – główne ulice miasta, V – granice miejskich odcinków rzek (objętych liczeniami)

In the Ujazdowski Park (Fig. 1: 2), 5 ha in area, the only water body was a small (0.4 ha) pond with concrete banks. In autumn, the pond was drained for several weeks. It was frozen over every winter. The number of old trees with holes in the trunks was small. Numerous people walking in the park were very often accompanied by unleashed dogs running freely. As in the former area, ducks were fed by the public — less intensively on weekdays than on Sundays and holidays.

Study plot the Skaryszewski Park (Fig. 1: 3) included the park proper (58 ha) and the adjacent Lake Kamionkowskie (20 ha). In the park there were two ponds (11 ha in total area), interconnected by a canal, with single, wooded islands. Except for small parts of Lake Kamionkowskie the water bodies froze over in winter. There were few holes in tree trunks. The characteristic feature of this plot was the presence of many loose dogs. The ducks were fed by a small number of people — in comparison to other areas, here they received the least food.

Study plot the Gocławski Canal (Fig. 1:4) was a part the canal 8 m wide and about 800 m long. In winter, large water-surface areas were free of ice. There were no sites suitable for nest building on the canal. Duck feeding was intensive, also on weekdays.

The Saski Garden (Fig. 1:5) was located right in the city centre. The only water body in this 16-hectare park (a concreted pond of 0.2 ha) froze up in winter. There were few old trees there, in considerable dispersion. There was no nest cover on the ground either. The park was visited by the largest number of people (at least several thousand a day). Duck feeding by the public in winter was here most intensive of all the areas analysed. At the same time many people used to come to the park with their dogs.

The study plots were used by mallards primarily during daytime. In the evening all, or nearly all mallards flew out of the city and returned early in the morning.

RESULTS

Abundance dynamics and sex structure over a yearly cycle

The course of abundance dynamics was in all the study years similar (Fig. 2). Every year the lowest numbers were seen in the breeding season. The proportion of males at the time of nesting season was similar every year, amounting to 56–60 %.

In the second half of May and June mallards, mainly drakes, grew in number. In the second half of June their proportion was 75–82 % of the birds seen on water. The number of flightless, moulting drakes was 350–450. Outside the study plots 100–150 males moulted in the Zoological Garden (Gilewska in litt.).

In summer and early autumn the numbers increased further to reach the peak level in September or October. The highest abundance in this period

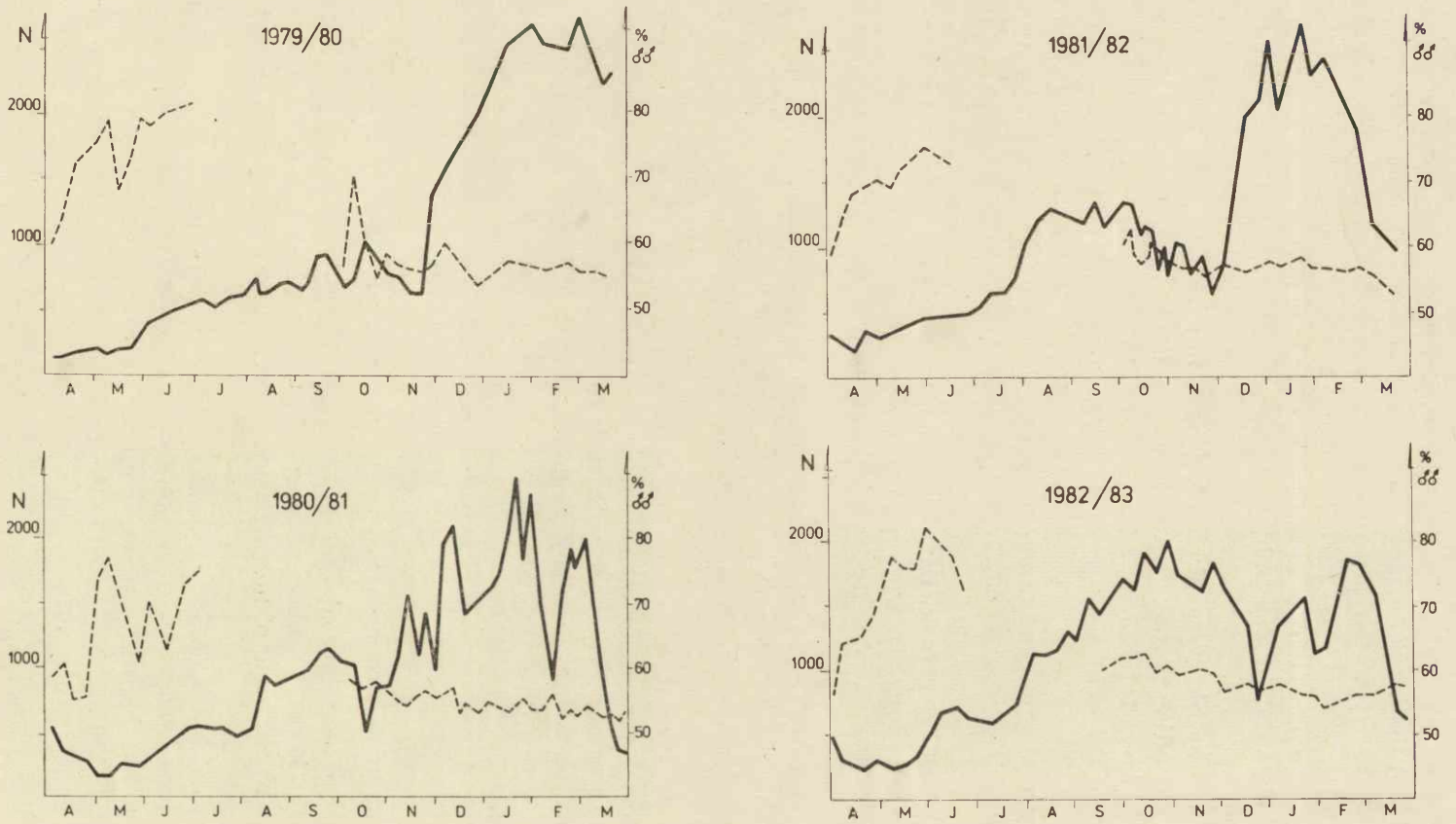

Fig. 2. Abundance dynamics of the mallard (solid line) and percentage of drakes (dashed line) in the permanent 5 areas jointly

Ryc. 2. Dynamika liczebności krzyżówki (linia ciągła) i udział samców (linia przerywana) na 5 stałych powierzchniach łącznie

of the successive study years was 1000, 1200, 1300, 2000 individuals. At the end of autumn or early in winter there occurred a short-termed reduction in numbers. In autumn the proportion of males ranged from 55 to 70%.

The highest numbers of mallards in the city were observed in winter. An exception was the mild winter of 1982/83 when the maximum winter numbers were lower than the autumn numbers. In winter the sex structure was stable amounting in the successive years to 57, 54, 57 and 56% males. The retreat of most mallards from the city in spring was very fast. It usually took place in the second half of March, but if low temperatures stayed a longer time, it might continue until mid-April.

Assessment of the wintering population and the effect of temperature on the number of mallards in the city

During the winters of 1980/81–1984/85 there were 2500–6000 mallards in Warsaw at daytime, thereof 1200–3200 in areas included in the urban category (Fig. 3). On the Vistula and on the Wilanówka a total of 100 up to 3400 birds stayed. Most of them concentrated on the lower stretch of the Vistula.

The highest numbers of mallards in urban areas were recorded in the middle of winter when waters outside the city froze over. Only in the winter of 1982/83 did the highest abundance occur in November, but the whole winter was then very mild. Ducks found in 5 permanent study plots represented 67–99% of the ducks present in urban areas. As their numbers increased, mallards

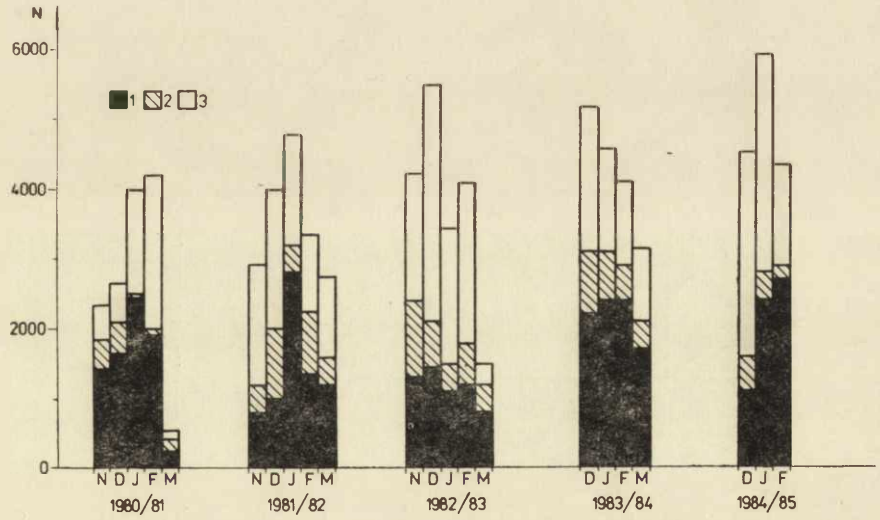

Fig. 3. Number of mallards in Warsaw in the winter period

1 – permanent study plots, 2 – other urban areas, 3 – the Vistula and the Wilanówka

Ryc. 3. Liczebność krzyżówki w Warszawie w okresie zimowym

1 – stałe powierzchnie próbne, 2 – pozostałe powierzchnie miejskie, 3 – Wisła i Wilanówka

tended to congregate in those plots at the same time retreating from some freezing-over water bodies in other urban areas (Fig. 3).

On account of the considerable variation in numbers observed in winter (Fig. 2), it was decided to analyse the relationship between temperature and the numbers of mallards in the study plots. Falling temperature was followed by an increase in numbers according to the equation:

$$N_i = 66.4\, t_i + 2597, \quad r = -0.51,$$

where N_i — total number of mallards for 5 study plots on a particular day (for the November-March period of 1979/80–1982/83), t_i — temperature on the day of counting, augmented by 15°C.

Regression and correlation coefficients appeared to be highly significant statistically ($p < 0.01$, test F).

A similar relationship was determined for mean monthly temperatures and mean monthly numbers (Fig. 4). The regression line equation was of the form: $N_j = -130.1\, t_j + 2979$ ($r = -0.75$, $p < 0.01$, test F), where N_j — mean monthly, in the November-March period, number of the mallard in 5 study plots jointly, t_j — mean monthly temperature, augmented by 10°C.

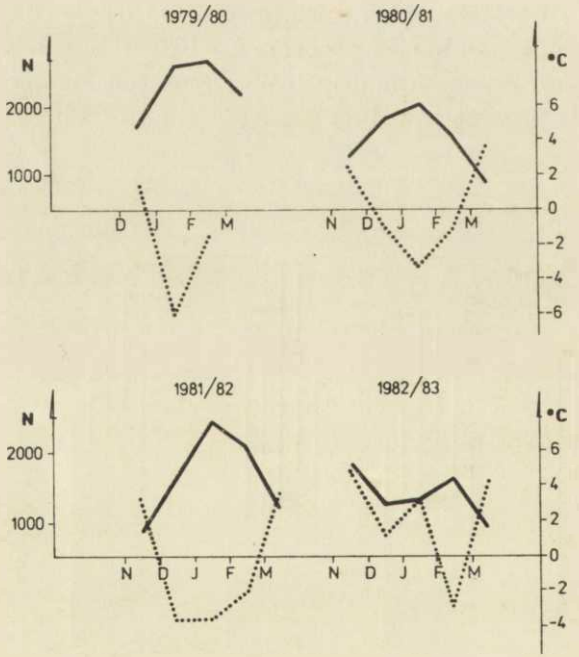

Fig. 4. Comparison of the mean monthly number of mallards (solid line) with the mean monthly of circadian temperatures in Warsaw (dashed line) for 4 winter periods

Ryc. 4. Porównanie średniej miesięcznej liczebności krzyżówek na powierzchniach próbnych (linia ciągła) ze średnią miesięczną przeciętnych temperatur dobowych w Warszawie (linia przerywana) dla 4 zim

Fecundity

The total size of the breeding population in Warsaw was estimated at about 100 pairs. It was very difficult to precisely estimate the number of females nesting in particular plots, whereas the results obtained with several independent methods were found to vary (KELLER *et al.* in press). The cause of this was primarily the presence, throughout the breeding season, of females which certainly did not breed in the plots that were checked. Depending on the plot and year, the proportion of this group of females varied between 20 and 35% of the total number of breeding females (KELLER *et al.* in press). The annual variation in the size of the breeding population was small — deviations from the long-term mean ranged from 4 to 20%, depending on the calculation method used.

Nearly all the 82 clutches found were in tree-trunk holes or in baskets. Only one nest was on the ground. In the years 1980–82 there were 19, 27 and 25 baskets available. Mallards occupied 16, 15 and 16, respectively, of them.

Egg laying began in the last 10-day period of March (1981, 1982) or in the first 10-day period of April (1980). The peak number of initiated clutches ussually occurred between April 1 and 10 (Fig. 5). Late clutches, initiated after the 10th May, in all years represented a small proportion of clutches: 1980 — 28%, 1981 — 11% and 1982 — 0%.

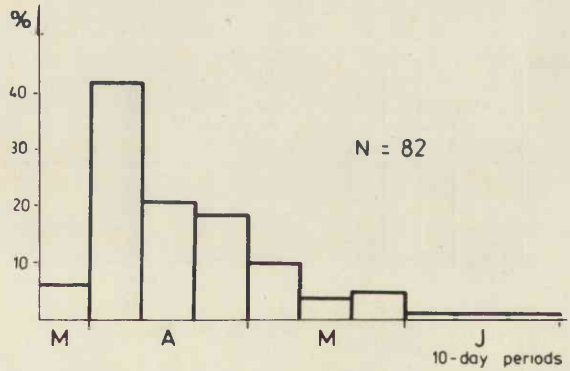

Fig. 5. Breeding onset chronology (according to the date of laying of the first egg) in Warsaw (data for the years 1980–82 jointly)

Ryc. 5. Chronologia rozpoczynania lęgów (wg terminu zniesienia pierwszego jaja) w Warszawie (dane z lat 1980–82 łącznie)

Complete single clutches consisted of 4–13 eggs each. The mean size of a clutch for three years jointly was 8.9 eggs ($N = 76$, $SD = 0.2$). Early clutches, started before May 10, were larger than late clutches: $\bar{x} = 9.1$, $SD = 0.2$, $N = 67$ and $\bar{x} = 7.0$, $SD = 0.5$, $N = 9$ ($p < 0.01$, STUDENT's t = test.

Nesting success was in all the study years high and amounted to 81% for three years jointly (79–84% in particular years). Total losses occurred more often

during egg laying, or during the first half of the incubation period than during the second half — 80 and 20%, respectively ($p < 0.01$, *Chi*-square test). The main causes of total losses were: nest desertion (80%) and nest destruction by man (20%). In successful clutches partial losses constituted 7% of laid eggs. These included: unhatched eggs — 3% and eggs lost during incubation — 4%. The average brood size at the time of hatching was 8.3 ducklings.

The mortality of young was high, the highest death rate falling on the first days of the ducklings' life. A comparison of the size of a brood aged 5–8 weeks (Fig. 6) with its size at the time of hatching indicated that ducklings' survival rate was equal to 51%. However, there were a large number of females which most likely did not rear a single young. This was indirectly indicated by the proportion of females with 1 duckling, in the total number of

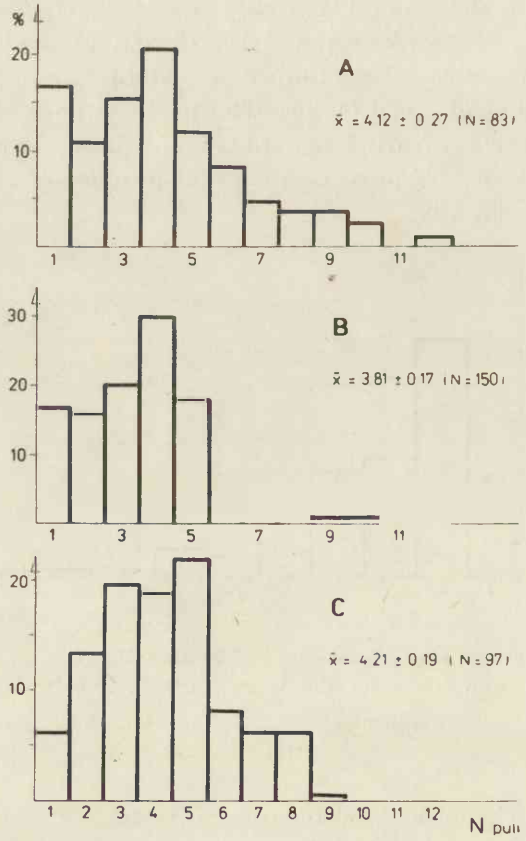

Fig. 6. Size of broods aged: 1–6 days (A), 1–4 weeks (B), 5–8 (C), data for the years 1979–82

Ryc. 6. Wielkość stadek rodzinnych w wieku: 1–6 dni (A), 1–4 tygodni (B) i 5–8 tygodni (C), dane z lat 1979–82

females with young; for broods aged 1–6 days this proportion was 17%, and for those aged 5–8 weeks only 6% (Fig. 6). It is estimated that the real mortality of ducklings was 70–80%.

The causes of these high losses have not been fully recognized. The main role was probably played by two factors. One of them was predation by rats which occurred in large numbers in the plots checked. The other factor, acting indirectly, was brood dispersal or separation of single ducklings which were thus deprived of the female's protection (ducklings without a female could often be seen, especially on a small pond in the Ujazdowski Park where the density of mallards was high).

With the estimated nesting success of 81% it may be assumed that 95% of females took their ducklings to water bodies. Assuming a survival rate of young of 20–30%, there were 1.6–2.4 reared young per breeding female per year.

Differences in the importance of particular study plots to mallards

The extent of utilization of the study plots by mallards varied. The differences concerned the size of the breeding populations, the role of the plot as a moulting ground, the level of numbers in summer and autumn, and the population size and percentage of males in winter.

The largest number of females (50–60) nested in the Łazienkowski Park. In the Skaryszewski Park 7–10 females nested, and slightly fewer — 4–8 in the Ujazdowski Park. Several females, observed every year on the Gocławski Canal with young, nested most likely in the allotments neighbouring with the canal. In the Saski Garden single pairs bred.

The most important summer moulting ground was the Łazienkowski Park, where 250–350 flightless drakes assembled. In the Skaryszewski and Ujazdowski parks there were 30–50 of them in each, and no flightless mallards were observed on the Canal and in the Saski Garden.

In summer and early autumn mallards were most numerous in the Łazienkowski Park: 400–1200 individuals. Their number in this period was almost equal to that observed in winter (Fig. 7). In the Skaryszewski and the Ujazdowski parks the number of mallards was low throughout the year (Fig. 7). On the Canal mallards were seen throughout the year; their number was small there in spring and summer, whereas the peak numbers occurred there in winter. In the Saski Garden ducks were in principle present only in the autumn-winter months (Fig. 7). Only in the period 1983–84 did a small number of individuals appear also in summer.

The study plots also differed in the percentage of males in the winter period (Fig. 8). Of the three plots compared: the Łazienkowski Park, Canal and Saski Garden (the plots were selected on account of the large numbers of birds

found in them, making it possible to calculate the sex structure each time for at least 200 individuals) the Saski Garden was found to hold the highest proportion of males. In the January-March period the differences between it and the other two plots were significant statistically ($p = 0.01$, *Chi*-square test). No differences were found between the Łazienkowski Park and the Canal.

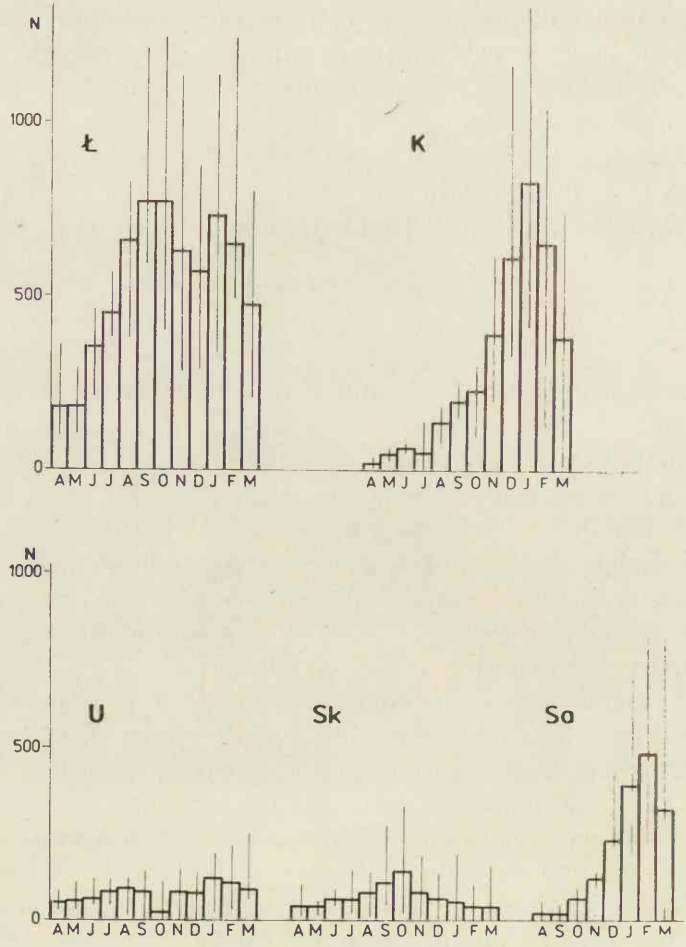

Fig. 7. Number of mallards in Łazienkowski Park (Ł), Ujazdowski Park (U), Skaryszewski Park (Sk), Saski Garden (Sa) and on Gocławski Canal (K)

The columns denote monthly means for the period 1979–1983 and the vertical lines delimit the range of variation in numbers

Ryc. 7. Liczebność krzyżówek w Parku Łazienkowskim (Ł), Parku Ujazdowskim (U), Parku Skaryszewskim (Sk), Ogrodzie Saskim (Sa) i na Kanale Gocławskim (K)

Słupki oznaczają średnie miesięczne z lat 1979–1983, linie pionowe wyznaczają zakresy wahań liczebności

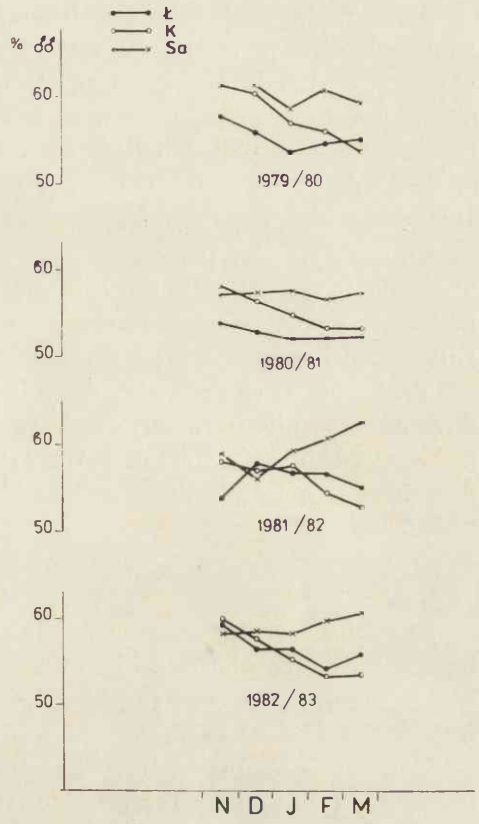

Fig. 8. Mean percentage, for particular winter months, of drakes n Łazienkowski Park (Ł), Saski Garden (Sa), and on Gocławski Canal (K)
Data for the years 1979–1983

Ryc. 8. Średni dla poszczególnych miesięcy zimowych udział samców w Parku Łazienkowskim (Ł), Ogrodzie Saskim (Sa) i na Kanale Gocławskim (K)
Dane z lat 1979–1983

DISCUSSION

Abundance dynamics and sex structure

In Warsaw, variation in numbers of the mallard over a yearly cycle was very similar to that in other urbanized areas in Europe (*e.g.* HANSSON 1966) and in North America (*e.g.* FIGLEY and van DRUFF 1982). During a year the lowest numbers of mallards in towns were found during the breeding season (HANSSON 1966, GYLLIN and LARSSON 1967, FIGLEY and van DRUFF 1982). In Göteborg no breeding females were found because of the lack of nesting sites (MATHIASSON 1971).

More ducks were found in towns outside the breeding season. Fairly common was the selection of urban habitats as moulting grounds. As in Warsaw, flocks of flightless drakes were found in Helsinki in summer (RAITASUO 1964), Lund (HANSSON 1966), urban parks of the state of Massachusetts (HEUSMANN 1981) and in Göteborg (MATHIASSON 1971). An increase in numbers observed in Warsaw in late summer and in autumn was also seen in other urbanized areas.

As in Warsaw, the highest abundance was in other towns recorded in winter. In Stockholm peak numbers occurred in periods preceding spells of frosty weather, and reduced numbers with dropping temperatures ENGSTROM (1961) attributed to migration to warmer areas. However, falling temperatures and freezing-over of water bodies as a rule were followed by increased numbers of mallards in towns (GYLLIN and LARSSON 1967, NILSSON 1968, KRUMBIEGEL 1969).

Changes in the percentage of males, observed during a year among the mallards in Warsaw, did not differ from those found in other towns (*e.g.* EYGENRAAM 1957, HANSSON 1966, MATHIASSON 1971), and areas outside towns (*e.g.* LUNIAK 1971).

Variation of the sex structure between the various study plots in Warsaw may have resulted from differences in their attractiveness and the effect, demonstrated by HEPP and HAIR (1984), of social dominance on the spatial distribution of mallards in winter.

The importance of the urban habitat to mallards during a year

Breeding season. The number of nesting females in Warsaw was not high, but as the areas of the parks and water bodies are small, the density of pairs was in some parks considerable. A favourable factor, by which the city differs from most natural habitats and which may attract breeding pairs, was almost total lack of nest predators. Differences in the number of breeding pairs in the particular study plots indicated differences in their attractiveness and depended primarily on the surface area of the water bodies and possibility to hide nests.

The main differences, as regards the ecology of the mallard, between Warsaw and natural habitats concerned nest location and predators' pressure on nests with eggs and on ducklings.

Under natural conditions mallards as a rule built nests on the ground, whereas a mass nesting in tree-trunk holes, like that seen in Warsaw, was exceptional (MAJEWSKI 1986).

Data for other towns indicate that in urban habitats breeding can begin earlier than in natural habitats (RAITASUO 1964, HANSSON 1966, FIGLEY and vanDRUFF 1982). Breeding in unusual seasons has also been recorded (MONTIER 1981, RINGLEBEN 1981). The season in which the mallards in Warsaw began breeding was not different from that recorded for natural habitats in Poland (KELLER 1985, MAJEWSKI 1986). The clutch size found by us did not differ from those reported by KELLER (1985) and MAJEWSKI (1986).

The high nesting success recorded in Warsaw resulted from the low pressure by predators: there were no mammalian predators, whereas the effect of a small number of corvids was limited by the fact that mallards nested in tree holes and baskets. Nesting success was also high in many other urban areas, and

where it was low, the losses were caused mainly by people and domestic animals or by nest desertion (examples from the paper by FIGLEY and vanDRUFF (1982). In nonurbanized habitats nesting success was usually low, ranging from 20 to 40% (DZUBIN and GOLLOP 1972, KELLER 1985, MAJEWSKI 1986). A higher success was recorded in areas of limited predators' pressure (HILDEN 1964, BALSER *et al.* 1969, SCHRANK 1972, DUEBBERT and KANTRUD 1974).

The causes of the high mortality of ducklings in Warsaw parks agree with earlier observations of rat predation in the Łazienkowski Park (PIELOWSKI 1957), as well as with the high mortality of young due to the effect of their overcrowding, reported from other areas by RAITASUO (1964) and by TITMAN and LOWTHER (1975). High death rates of young were found in many other urban areas (RAITASUO 1964, HANSSON 1966, FIGLEY and vanDRUFF 1982). In natural areas losses of ducklings were usually far lower, rarely exceeding 20–40% (DZUBIN and GOLLOP 1972, KELLER 1985, MAJEWSKI 1986), although total losses of broods may sometimes exceed 50% (TALENT *et al.* 1983).

Post-breeding period. When looking for moulting grounds mallard drakes are attracted first of all by the presence of shelter against winged predators, protection against mammalian predators and presence of sites for drying their bodies (PANEK and MAJEWSKI 1985). According to the last-quoted authors, food availability is of secondary importance, although other authors consider this factor to be equally important (ORING 1964, SALOMONSEN 1968).

In Warsaw, moulting drakes were safe because there are no winged or mammalian predators of adult ducks there, and sites to dry feathers are not difficult to find. As they are not very shy, these birds use for this purpose not only islands, but also pond banks and lawns. Since feeding by the public was sporadic in summer, it could not play the role of a factor making the parks of Warsaw attractive to moulting drakes.

In late summer and in autumn mallards choose water bodies for their daytime rest, since these ensure safety (LUNIAK 1971, NOWYSZ-WESOŁOWSKA 1976). During the hunting season they prefer water bodies where hunting is not done, and they avoid those visited by hunters (THOMAS 1976). The high summer and autumn numbers of mallards in Warsaw, in some areas equal to or higher than the winter numbers (Łazienkowski, Ujazdowski, Skaryszewski parks), although feeding was sporadic, indicates that safety was the main factor making the city attractive in that period. A factor attracting birds from outside the city was no doubt the mallards which stayed in parks after breeding and moulting: in autumn the largest number of mallards were found in the Łazienkowski Park, so it was there that the largest number of nesting and moulting individuals were present.

Wintering. As in Warsaw, an increase in numbers with dropping temperatures was also found in other towns (HANSSON 1966, GYLLIN and LARSSON

1967, KRUMBIEGEL 1969). In Sweden, more mallards stayed in urban habitats during severe than during mild winters (NILSSON 1975). These data indicate that staying at daytime in towns is more advantageous for the maintenance of the mallards' energetic balance than staying in other habitats.

The majority of authors are of the opinion that feeding by the public is the main factor causing synurbization of the mallard (LUNIAK *et al.* 1964, HANSSON 1966, GYLLIN and LARSSON 1967, HAUKIOJA and SOIKKELI 1970, NILSSON 1975, FIGLEY and vanDRUFF 1982). But no calculation has so far been made of the quantity of food supplied to ducks in relation to their needs and amount of food eaten on countryside feeding grounds. A large proportion of the mallards staying at daytime in winter in Warsaw were not interested in the food supplied by the public. Many mallards wintering on a developed lagoon did not accept food given to them, and at the same time many of them left for the night (FIGLEY and vanDRUFF 1982). Night feeding of mallards outside towns was observed by HOHN (1948) and HANSSON (1966).

On the other hand, in winter ducks improve their energetic balance by reducing their activity (PRINCE 1979). This becomes particularly conspicuous at low temperatures or increased wind velocity (RAITASUO 1964, JORDE *et al.* 1984). We think that the more advantageous energetic balace of the mallards staying at daytime in Warsaw resulted from the possibility of reducing their activity in safe areas, staying in habitats of a higher temperature and lower wind velocity and receiving additional food.

CONCLUSIONS

1. The number of mallards present in the city in the breeding season was lower than during other seasons, although in some parks their density may have been considerable. The main breeding-ecology difference between the synurban population and populations from nonurbanized habitats was that in the city predators pressure on nests was insignificant and duckling mortality was very high. No differences were found in the chronology of egg laying or clutch size.

2. Some city parks were attractive moulting grounds for several hundred drakes from outside Warsaw.

3. In late summer and in autumn Warsaw was an important daytime-rest place for mallards.

4. The largest number of mallards stayed in the city in winter. Temperature fall was then followed by an increase in numbers.

5. Duck safety in the urban environment was the main environmental factor causing synurbization of the mallard.

ACKNOWLEDGEMENTS

We thank members of the Ornithological Section of Forestry Students' Research Society, Agricultural University of Warsaw, and all other persons who helped us count mallards and check their nests. Our cordial thanks are extended to Roman Andrzejewski for extensive assistance in the research, and to Przemysław Majewski, Marek Panek and Zygmunt Pielowski for valuable criticism of the initial version of the paper.

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STRESZCZENIE

[Proces synurbizacji krzyżówki *Anas platyrhynchos* w Warszawie]

Ze względu na postępujący proces synurbizacji (adaptacja do warunków środowiska miejskiego i zmiany zachodzące w obrębie populacji miejskich) krzyżówek w Warszawie, podjęto badania mające na celu określenie charakteru i przyczyn wykorzystania przez nie terenów miejskich Warszawy. W latach 1979–83 prowadzono cotygodniowe liczenia kaczek w pięciu najważniejszych miejscach ich występowania: parki — Łazienkowski, Ujazdowski, Skaryszewski, Ogród Saski i 800-metrowy odcinek Kanału Gocławskiego. W ciągu czterech zim 1980–85 liczono krzyżówki raz w miesiącu na zdecydowanej większości potencjalnych terenów ich przebywania w mieście (ryc. 1). W sezonach lęgowych 1979–82 badano ekologię rozrodu miejskich krzyżówek.

Dynamika liczebności na wszystkich pięciu powierzchniach łącznie była co roku podobna (ryc. 2). Najniższą liczebność stwierdzono w sezonie lęgowym (kwiecień–maj), ale zagęszczenie par mogło być w niektórych parkach znaczne. W całej Warszawie było około 100 par lęgowych. W drugiej połowie maja i w czerwcu następował wzrost liczebności spowodowany przylotem kilkuset kaczorów na pierzenie. Najwięcej nielotnych samców przebywało w Parku Łazienkowskim. Latem i jesienią w dalszym ciągu rosła liczba krzyżówek w mieście, które zapewniało im bezpieczne miejsce dziennego odpoczynku. Największą liczebność corocznie stwierdzano w środku zimy. W całej Warszawie zimowało 2500–6000 krzyżówek, 1200–3200 z nich na terenach miejskich (z czego 67–99% na pięciu stałych powierzchniach próbnych), a pozostałe na podmiejskich — Wisła i Wilanówka (ryc. 3). Obniżenie temperatury powodowało wzrost liczebności krzyżówek (ryc. 4), co wskazuje, że przebywanie w ciągu dnia w mieście jest dla utrzymania ich bilansu energetycznego korzystniejsze niż przebywanie w innych siedliskach.

Zmiany struktury płci w cyklu rocznym (ryc. 1) nie różniły się od zmian stwierdzonych na terenach naturalnych.

W parkach miejskich samice gnieździły się na drzewach — w dziuplach i koszach lęgowych. Pierwsze zniesienia były rozpoczynane w ostatniej dekadzie marca, a szczyt rozpoczynania składania jaj następował w pierwszej dekadzie kwietnia (ryc. 5). Średnie zniesienie wynosiło 8,9 jaj ($N = 75$, $SD = 0{,}2$). Zniesienia rozpoczęte przed 10 maja były większe od późniejszych. Sukces gniazdowy wynosił 81%, a presja drapieżników jaj była nieznaczna. Straty całkowite wynikały z porzucenia gniazda (80%) lub zniszczenia go przez człowieka (20%). Stwierdzono bardzo wysoką śmiertelność piskląt (70–80%), w czym duży udział miały straty wszystkich piskląt w poszczególnych stadkach.

Stałe powierzchnie próbne różniły się między sobą liczebnością par lęgowych, rolą jako pierzowiska, liczebnością jesienną i zimową (ryc. 7) oraz strukturą płci w zimie (ryc. 8). Różnice te wynikały z różnych warunków środowiskowych poszczególnych miejsc.

Zestawienie wyników otrzymanych w tej pracy ze znanymi wymaganiami środowiskowymi krzyżówki w cyklu rocznym doprowadziło do konkluzji, że o atrakcyjności miasta decydowało przede wszystkim bezpieczeństwo kaczek (brak presji drapieżników i myśliwych). Dodatkowy pokarm oraz możliwość przebywania w środowisku o nieco wyższej temperaturze mogły również przyciągać kaczki zimą.