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Tomasz BUCZEK, Marek KELLER

Breeding ecology of the Marsh Harrier *Circus aeruginosus* in eastern Poland. Part 1. Population numbers and phenology of the onset of laying

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Abstract. Studies were carried out in two types of habitat: at retention reservoirs (1979–1986, 2 areas covering 616 ha in total) and on low bogs of the carbonate type (1986–1988, 1990 and 1992, 3 areas covering 1049 ha in total). Studies involved annual counts of the breeding population, and frequent checks on nests. In 6–7 years, breeding population increased in all areas by 17–179%. Maximum densities were 5 pairs/100 ha at retention reservoirs and 7.3 pairs/100 ha on bogs. The authors account for the increase in numbers by reference to the cessation of the use of DDT and to a decrease in the intensity of shooting. The peak period for the onset of laying occurred in the last 5 days of April (with the median data being 29th). Median dates for the onset of laying in a given year were correlated with temperature and the amount of precipitation in April. In addition, they were also related to populations of the Common Vole *Microtus arvalis*. Cumulative curves for the onset of laying by individual pairs were close to the cumulative curves for temperatures above 0°C, but were shifted in time by 6–10 days.

Key words: birds of prey, Marsh Harrier *Circus aeruginosus*, breeding ecology, dynamic of numbers, onset of laying.

* W. Żywnego 1/32, 20–854 Lublin, POLAND

** Dept. of Forest Zoology & Wildlife Management, Warsaw Agricultural Univ., Rakowiecka 26/30, 02–528 Warsaw, POLAND.

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INTRODUCTION

The last two decades have seen increases the populations of Marsh Harriers in Europe (Underhill-Day 1984, Jorgensen 1985, Gensbol 1986, Bekhuis *et al.* 1987, Kjellen & Schubert 1987, Mattas 1988, Bavoux *et al.* 1989). Poland has also witnessed such changes (Dyrcz *et al.* 1984, Witkowski 1989). This has made it possible for more detailed population studies to be carried out now, than was the case in previous decades.

This paper presents data on the changes in the numbers of two populations of Marsh Harrier and analyses the factors conditioning the dates of the onset of laying by them. The latter issue is of particular significance because birds of prey have long incubation periods, and their nestlings spend a long time in the nest. Thus the onset of laying: (1) defines the possibilities for the onset of repeat laying in a case in which the first brood or clutch is lost, and (2) is connected, through the influence of various environmental factors, with the productivity of the brood realized (Newton & Marquiss 1984, Newton 1986). Other results of authors studies on ecology of the Marsh Harrier have been presented in the work (Buczek & Keller 1994), which is concerned with breeding success. Further papers will be concerned with brood productivity and with the progress of the growth of nestlings.

STUDY AREAS

Studies were carried out in the years 1979–1992 in five areas situated within the physiogeographic mesoregion of Polesie Lubelskie (Kondracki 1978), in the Lublin region (Fig. 1). The work was done in two types of habitat: at artificial retention reservoirs and in carbonate bogs (Keller 1985, Buczek & Buczek 1993a). The Zahajki retention reservoir (area Z) occupied a total area of 234 ha and had a 20–25% cover of reedswamp communities *Phragmitetea*. The dominant species were the common reed *Phragmites australis* and the reedmaces *Typha latifolia* and *T. angustifolia*. Also charac-

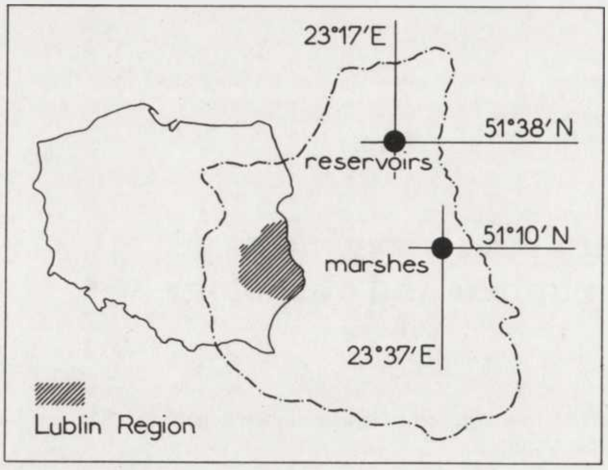

Fig. 1. Location of the study areas.

[Ryc. 1. Położenie powierzchni badawczych.]

teristic was the significant representation of flooded scrub with willows, *Salix spp*. Dominant in the general area of the reservoir were extensive complexes of forests and meadows (Tab. 1).

Table 1. Percentage of different types of habitat 4 km around the study area. Participation in the structure of feeding grounds are given in brackets (forests and villages are excluded).

[Tabela 1. Udział procentowy różnych środowisk w promieniu 4 km od badanych powierzchni. W nawiasach podano udział w strukturze żerowisk (z wyłączeniem lasów i wsi).]

	Plots				
	Z	M	G	R	B
Forests	36	39	20	11	18
Villages	2	1	10	2	4
Open water	8	10	<1	–	–
	(13)	(16)	(>1)	–	–
Bogs					
–drained bogs	–	–	4	3	6
	–	–	(5)	(4)	(8)
–natural-state bogs	–	–	3	11	7
	–	–	(5)	(12)	(9)
Meadows	29	19	25	26	17
	(47)	(31)	(36)	(29)	(22)
Cultivated fields	25	32	37	47	47
	(40)	(53)	(53)	(54)	(61)

The Mosty retention reservoir (area M) is located 3 km north of the Zahajki reservoir and covers 382 ha. About 40% of the area of the reservoir is taken by plant communities similar to those in area Z. However, there is a greater representation of cultivated fields around this reservoir (Tab. 1).

In their general character, both reservoirs bore some resemblance to neglected fishponds. The characteristic features differentiating them from the bogs were:

– the presence of large areas of open water,

– the occurrence of aquatic birds in large numbers, – particularly in the case of the Coot *Fulica atra* and the species of Grebes *Podiceps cristatus* and *P. grisegena* (Keller 1985),

– the widespread occurrence of the introduced American catfish *Ictalurus nebulosus*. Dead individuals of this species were noted in large numbers on the surface of the water – especially in the period May–June. These have been found to constitute a significant component of the diet of Marsh Harriers in similar habitat elsewhere (Buczek & Keller – unpubl. data).

Of the 126 nests founded in the retention reservoirs, 65% were placed in reedbeds, 9% in patches of reedmace and 26% in scrubby willows at heights of between 0.2 and 1 m above the surface of the water.

The Gotówka Bog (area G) covers 218 ha. 85% is covered with thick patches of the twig rush *Cladium mariscus*, occurring here in the association *Cladietum marisci*. The remaining area consists of reedbeds. The bog is situated in a rural landscape with a predominance of fields (Tab. 1).

Brzeźno Bog (area B) covers 230 ha and is made up of a mosaic of patches of swamp vegetation with twig rush (which cover 90% of the area), as well as meadows of a xerothermic character, and tree cover on elevated terrain in the middle of the bog. The surrounding area is dominated by cultivated fields (Tab. 1).

The Roskosz Bog (area R) covers a total of 601 ha, of which about 71% is covered by dense swamp vegetation with twig rush and an admixture of reeds. The remaining area is covered by *Magnocaricion* associations of the twig rush as well as reedbeds and islets with forest and steppe vegetation. The main types of vegetation in the vicinity of the bog are cultivated fields and meadows (Tab. 1).

In addition, the bogs referred to were characterized by:

– a water table which varied both between years and as part of an annual cycle,

– the burning (outside the breeding period) of considerable areas of reeds and swamp vegetation in some years (1987, 1990 and 1992),

– a great abundance of passerine birds *Passeriformes* and of waders *Charadrii* (Buczek & Buczek 1993b).

Of the 147 nests founded in bogs, some 92% were built in twig rush, even if this species occurred only as an admixture in another plant community. The remaining 8% of nests were founded in dwarf willows growing amongst the swamp vegetation with twig rush.

METHODS

Studies were carried out at the retention reservoirs in the years 1979–1986, and on the bogs in the seasons 1986–1988, 1990 and 1992 (to a limited extent). Research involved the annual evaluation of the size of the breeding population, the search for the maximum possible number of nests and regular checks on these nests. Almost all nestlings were ringed and some were also marked with wing-tags (Picozzi 1971). Field observations commenced from the moment that the harriers returned from their wintering grounds. The peak arrival time was the last third of March, and the earliest sighting was made on March 14th (in 1987). In the periods of courtship and nest building, all sightings were marked on 1:10 000 scale maps. As a rule, the estimation of the breeding population was based mainly upon the nests discovered. Only a small number (6%) of pairs whose nests were not found were categorized as breeding birds on the basis of the behaviour of adults or the sighting of young in flight.

Nests were first checked during the laying period, and this made it possible for the date of the onset of laying to be determined precisely. In the case of nests found after incubation had started, the date of laying of the first egg was determined on a preliminary basis using the water test (according to the author's own scale) and/or by reference to the degree to which the eggs were dirty. Dates determined in this way were later verified by calculation based on the date of hatching and a key for assessment of age on the basis of the length of the fifth primary and on the assumption that the average length of the incubation period was 33 days (Witkowski 1989, author's data). The dates of the onset of laying were then established to within 5 days. It was the middle day of these five days that was adopted in the calculation of median dates for these clutches.

Nests were checked at least once a week during the incubation period, and as a consequence it was possible to follow the fate of clutches and to determine the reaction of birds to possible losses of clutches or broods. It was then possible to find the nests of pairs which were repeat breeding, and to determine the dates on which this process began.

In characterizing the structure of the feeding grounds of Marsh Harriers around the nest site it was assumed arbitrarily that the birds hunted in an area around the nest with a radius of 4 km, according to author's own observations.

In analyzing the influence of meteorological factors on the phenology of breeding, use was made of data from the agrometeorological station in Uhrusk, which is located in the middle of the areas studied.

SIZES OF BREEDING POPULATIONS

Reported to occur within the study period were between 16 and 27 pairs of Marsh Harrier at the retention reservoirs, and between 23–28 and 58–64 on the bogs (Tab. 2).

Table 2. The numbers of the breeding pairs in study plots.

[Tabela 2. Liczebność par lęgowych błotniaka stawowego na badanych powierzchniach.]

	Reservoirs		Bogs		
plots	Z	M	G	R	B
ha	234	382	218	601	230
1979	6				
1980	6				
1981	6	10			
1982	6				
1983	7	8			
1984	5	19			
1985	8	19			
1986	7	17	6	14-19	3
1987			9	23	4
1988			14	24	6
1990			12	39	2
1992			14-15	40-44	4-5
Max. density p/100 ha	3.4	5.0	6.9	7.3	2.6
Increase (years)	17% (7)	70% (5)	142% (6)	179% (6)	50% (6)

An increase in the number of breeding pairs was observed in all the areas studied. Within the 5–7 years the size of this increase ranged from 17% to 179% (Tab. 2). Numbers at retention reservoirs probably stabilized in the years 1984–1986, but the increase continued in the bog areas. A reduction in the rate of increase noted in 1990 in areas G and B was the result of the burning of respectively 43% and 85% of the areas occupied previously by harriers. A further increase in the number of breeding pairs was noted in area R during this same period, in spite of the fact that some 22% of this area was also burnt.

The maximum densities of breeding pairs reported from the study areas are between 2.6 and 7.3 per 100 ha (Tab. 2)

PHENOLOGY OF THE ONSET OF LAYING

First clutches and replacement clutches

The average dates for the onset of laying obtained from all areas and all years were characteristic for eastern Poland. The earliest onset of laying was noted on April 14th (in 1990) and the latest on May 18th (in 1987 and 1988). The peak for the onset of laying was noted between April 26th and 30th (Fig. 2), and the

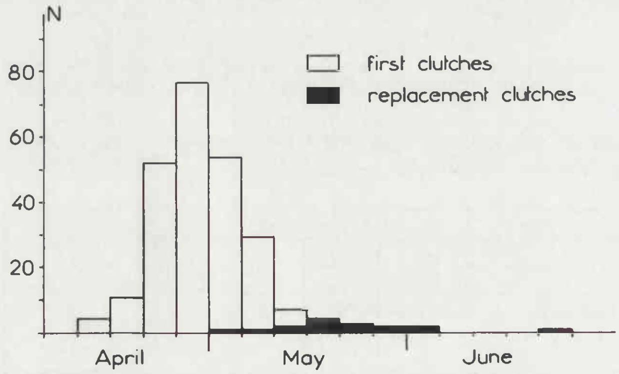

Fig. 2. Dates for the onset of laying by Marsh Harriers (combined data for all areas and all years).

[Ryc. 2. Terminy przystępowania błotniaków stawowych do lęgów (połączone dane dla wszystkich powierzchni i lat).]

median date was April 29th (N = 241). Repeat layings began between May 1st and 5th (N = 16), and the latest date for renesting was June 20th (in 1987). In the latter case, the young fledged at the beginning of September.

Differences between years

The earliest onsets of laying in the different years occurred between April 14th (in 1990) and April 30th (in 1980 and 1982). The peak time for the onset of laying was most often noted between April 26th and 30th (Fig. 3). Median dates were between April 26th and May 7th. In "early" years, the latest onset of laying occurred between May 1st and 5th, and in "late" years between May 16th and 20th.

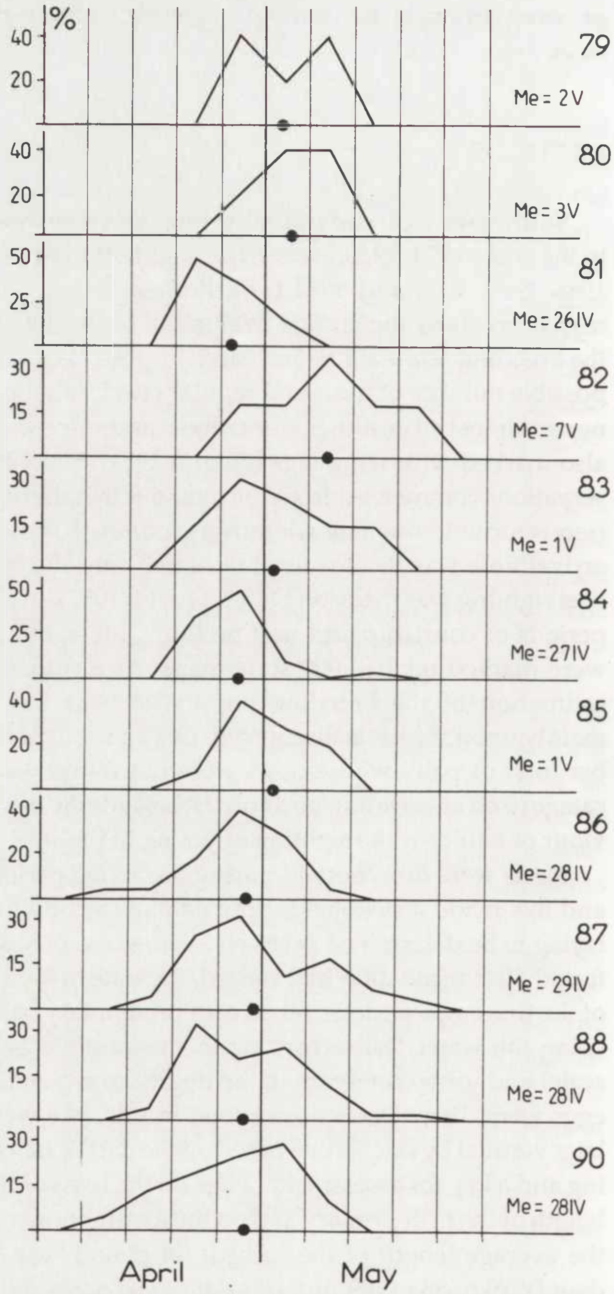

Fig. 3. Dates of the onset of laying by Marsh Harriers in different years (first clutches only). The dot represents the median in a given year.

[Ryc. 3. Terminy przystępowania błotniaków stawowych do lęgów w poszczególnych latach (tylko pierwsze lęgi). Kropka oznacza medianę w danym roku.]

The period to the onset of laying by Marsh Harriers ranged in different years from 15 to 35 days. It was correlated negatively with the date of the earliest onset of laying in a given year ($r = -0.70$, $p < 0.01$, $N = 11$ years) as well as with the numbers of breeding pairs ($r = -0.80$, $p < 0.01$). However, no relationship was noted with the median date ($r = -0.21$, not significant).

Table 3. Coefficients of correlation between the atmospheric factors and the median date.

[Tabela 3. Współczynniki korelacji dla zależności pomiędzy czynnikami meteorologicznymi a datą medialną.]

	Periods in April		
	1–21	8–21	15–21
A. Mean temperature	$r=-0.40$	$r=-0.59$	$r=-0.32$
	$p>0.1$	$0.02<p<0.05$	$p>0.1$
B. Days with rain	$r=-0.51$	$r=-0.41$	–
	$0.05<p<0.1$	$p>0.1$	–
A+B	$R^2=0.40$	$R^2=0.49$	–
	$p=0.12$	$p=0.06$	–

tation in the pre-breeding period on the dates of the onset of laying. Account was taken of mean daily temperatures, and the numbers of days with precipitation, in the period between the date on which birds returned from the wintering grounds (with April 1st being adopted arbitrarily) and the average date on which the first clutches were laid. Analysis was carried out for three variants: April 1st to 21st, April 8th to 21st and April 15th to 21st (Tab. 3, Fig. 4). The highest values of correlation coefficients were obtained for temperatures in the period April 8th to 21st and for precipitation in the period April 1st to 21st. Coefficients for multiple correlation were highest when account was taken of the temperatures between April 8th and 21st and the precipitation between April 1st and 21st ($R^2 = 0.52$, $p = 0.04$).

Material from Romankow-Żmudowska (1991) and Romankow-Żmudowska & Grala (1990), concerning the long-term dynamics of populations of the Common Vole, *Microtus arvalis*, were used as a basis for comparison of the

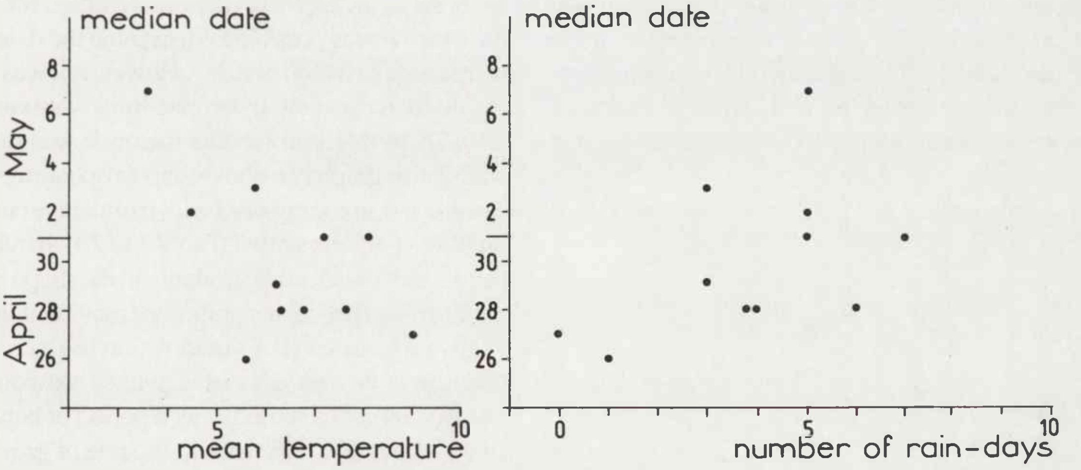

Fig. 4. Relationship between mean temperature in the pre-breeding period (8–21 April) and median date, and between number of days with precipitation (1–21 April) and median date (see also Tab. 3).

[Ryc. 4. Zależność pomiędzy średnią temperaturą w okresie przedlęgowym (8–21 IV) a datą medialną oraz pomiędzy liczbą dni z opadami (1–21 IV) a datą medialną (patrz również tab. 3.).]

There were significant differences in the median dates in the different years (Kruskall-Wallis test for one-way ANOVA: $KW = 28.52$, $p < 0.002$). In seeking reasons to explain these differences, analysis gave consideration to the influence of temperature and precipi-

median dates for the onset of laying in "vole" and "non-vole" years (Fig. 5). It was found that harriers did start breeding considerably (3.7 days) earlier in the "vole" years 1981, 1984, 1987 and 1990, than in the remaining years (two-sample t-test, $t = 2.64$, $p < 0.05$).

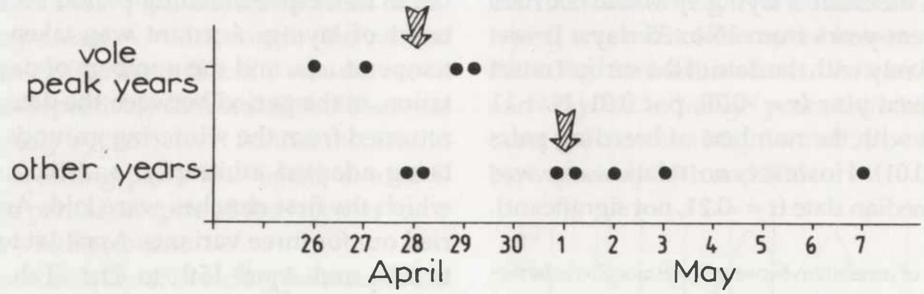

Fig. 5. Median dates of the onset of breeding by Marsh Harriers in "vole" and "non-vole" years. Arrows indicate the means calculated for medians from the different types of year.

[Ryc. 5. Daty medialne przystępowania błotniaków stawowych do rozrodu w latach "mysich" i "nie-mysich". Strzałkami oznaczono średnie obliczone dla median z poszczególnych typów lat.]

Differences between areas

For the purposes of the analysis, data for all years were combined. No significant differences were noted for the dates of the onset of laying in the different areas (one-way ANOVA, $p = 0.45$). The only significant difference found was between areas Z and M, which were close to each other (one-way ANOVA, $F = 4.27$, $p < 0.05$). When seeking to account for this difference, note was taken of the relationship between the structure of the feeding grounds accessible in the vicinity of a given area and the median date for laying by harriers in that area. A tendency was noted for harriers to nest earlier in areas with a greater representation of meadows (with drained bogs being treated as meadows). However, this relationship did not achieve statistical significance ($r = -0.77$, $p > 0.13$, $N = 5$, see Fig. 6).

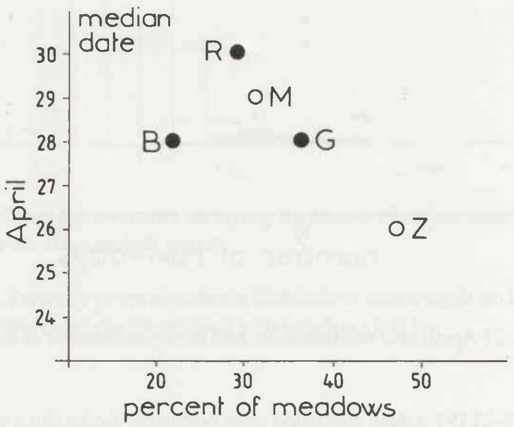

Fig. 6. Relationships for the different study areas, between percentage representation of meadows in the structure of the feeding grounds and the median date of the onset of laying. Empty circles represent the retention reservoirs and full circles the bogs.

[Ryc. 6. Zależność pomiędzy procentowym udziałem łąk w strukturze żerowisk a datą medialną przystępowania do lęgów na poszczególnych powierzchniach badawczych. Puste kółka oznaczają zbiorniki retencyjne, kółka pełne – torfowiska.]

The influence of the temperatures

The influence of the course of temperatures in April on the onset of laying by harriers was studied for the 4 years for which it was possible to determine the dates of laying of first eggs to within one day. However, it was found that graphs for mean daily air temperatures were very irregular (Figs 7.1 to 7.4), and for this reason it was decided that cumulative graphs for above-zero temperatures should be constructed, and compared with cumulative curves for the number of broods started (Figs 7.1 to 7.4). In all four years there is the considerable similarity in the shape and form of both curves. Particular significance may be attached to the following features: (1) a slowdown in the increase in temperature is always associated with a slowdown in the number of broods started, after a period of between 6 and 10 days, and (2) an increase in the rate of growth of temperature is associated with new laying after a period of between 8 and 9 days. Time divisions read in this way were transferred to graphs for mean daily temperatures and precipitation, and it emerged that falls in temperature connected with a slowdown in the onset of laying were always accompanied by precipitation. Furthermore, the onset of laying occurred in periods characterized by rising temperature and a lack of precipitation. Analyses of the correlation between the aforementioned atmospheric factors and the onset of laying by harriers do indicate a quite considerable similarity when the factors are analyzed separately or jointly (coefficients ranged from 0.4 to 0.6, see Tab. 3).

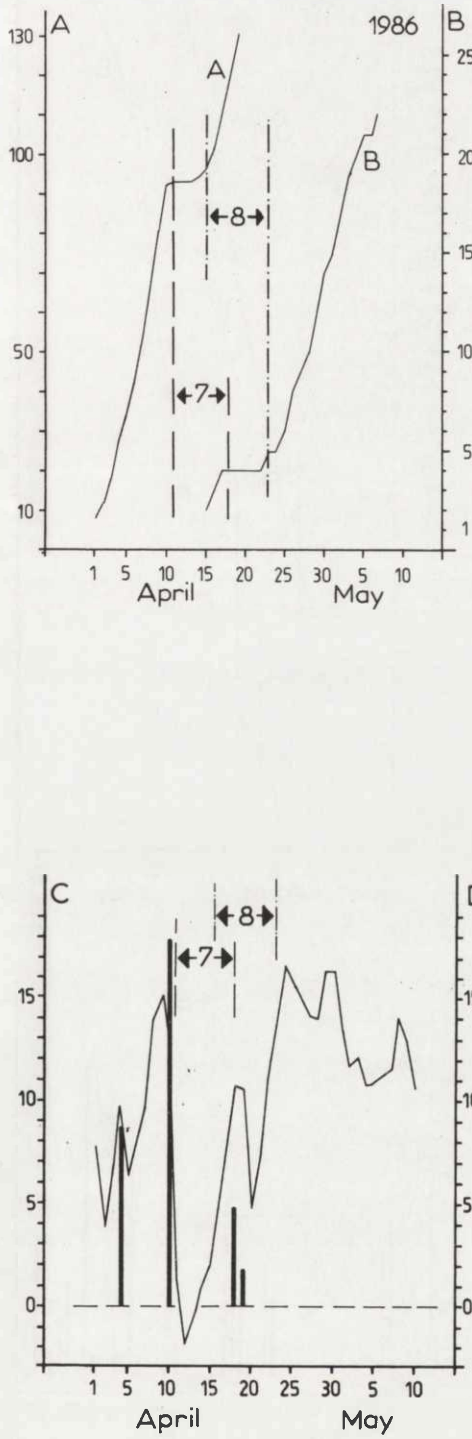

Fig. 7.1

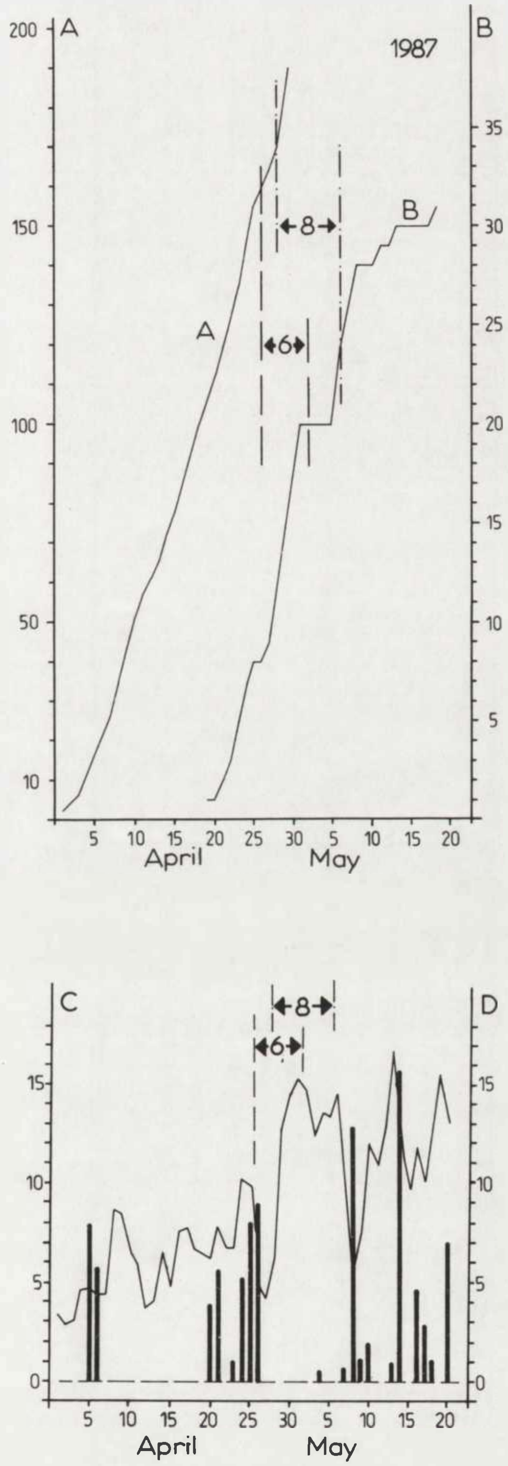

Fig. 7.2

Fig. 7. Cumulative curves for the course of temperatures above zero (A) and cumulative curves of the number of pairs which had started breeding (B), as well as graphs of mean temperature (C) and amount of precipitation (D). Read from the upper graphs are the number of days between the cessation in the increase in temperature and the cessation of new breeding, as well as the number of days between the onset of an increase in temperature and the onset of laying by further pairs (marked with arrows). The sizes of these shifts have also been marked on the lower graphs. 7.1 – 1986, 7.2 – 1987, 7.3 – 1988, 7.4 – 1990.

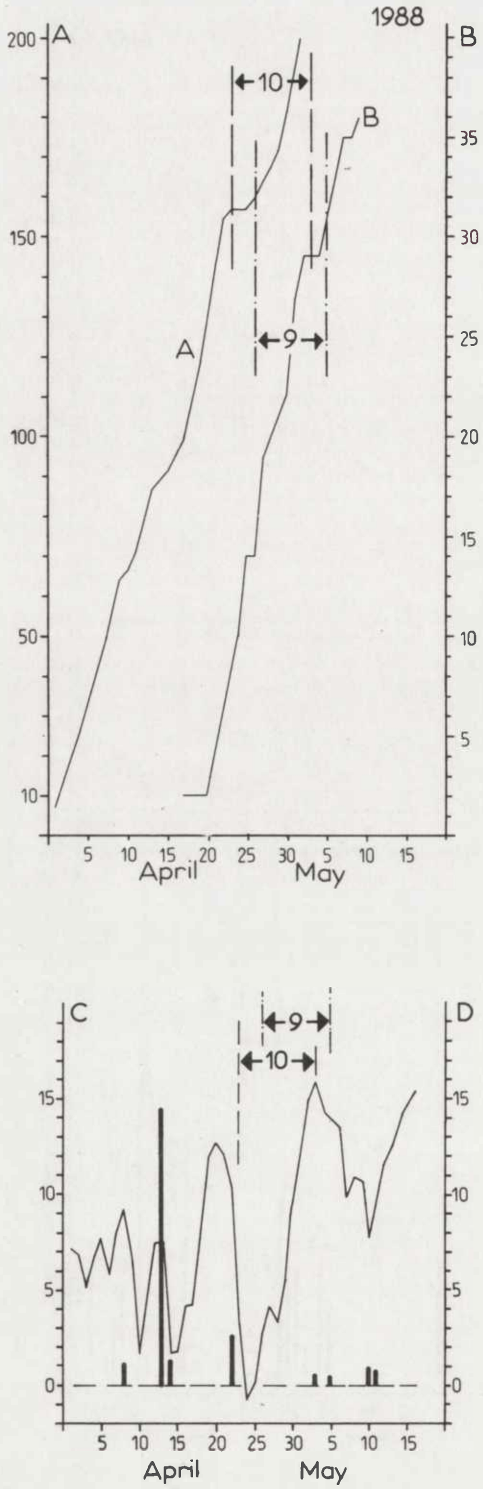

Fig. 7.3

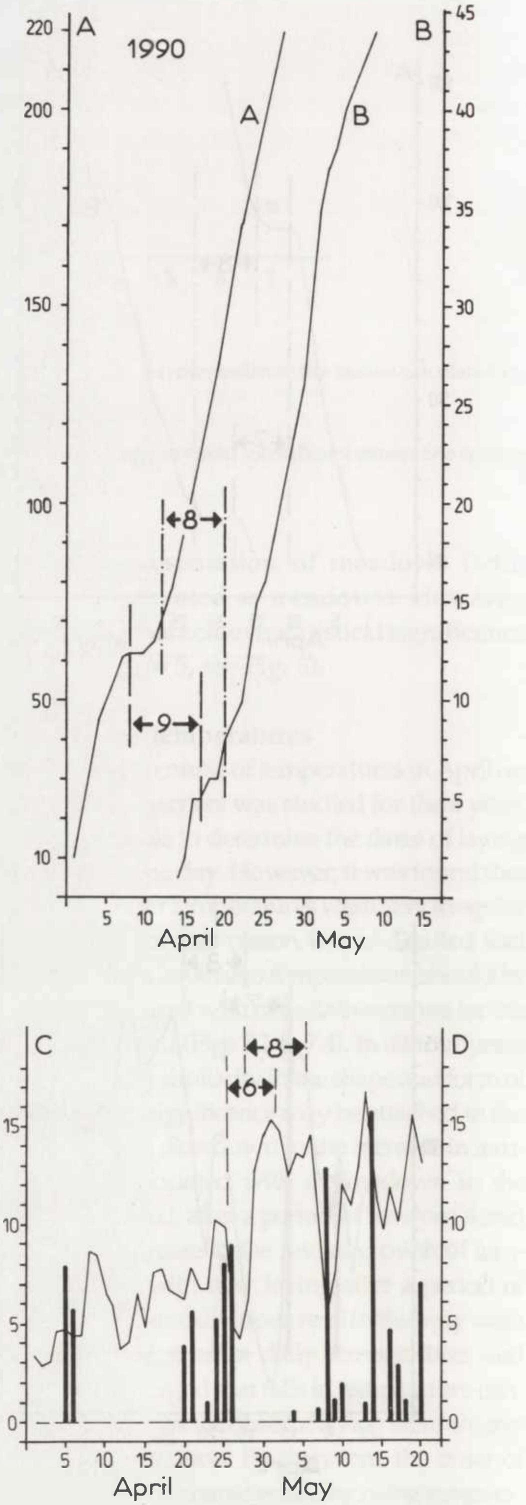

Fig. 7.4

[Ryc. 7. Kumulowane krzywe przebiegu temperatur dodatnich (A) i kumulowane krzywe liczby par przystępujących do lęgów (B) oraz wykresy średnich temperatur (C) i wielkość opadów (D). Z wykresów górnych odczytano liczbę dni pomiędzy zahamowaniem wzrostu temperatur a zaprzestaniem podejmowania lęgów przez błotniaki oraz liczbę dni pomiędzy początkiem wzrostu temperatur a podjęciem lęgów przez kolejne pary (zaznaczone strzałkami). Wielkość tych przesunięć zaznaczono również na wykresach dolnych. 7.1 – 1986, 7.2 – 1987, 7.3 – 1988, 7.4 – 1990.]

DISCUSSION

Size of the breeding population

The most precise data on long-term population trends for Marsh Harriers in Poland come from the Biebrza Marshes, from the Milicz ponds (in western Poland) and from Siemień (eastern Poland). In the Biebrza Marshes, numbers rose from around 30 to around 80 in the period between 1966–68 and 1980 (Dyrcz *et al.* 1984). In Milicz, the number of breeding pairs rose from 30 to 50 between 1972 and 1984 (Witkowski 1989), and in Siemień there were 2–4 pairs in 1968 (Dyrcz *et al.* 1973, Kot 1981) and 25–28 pairs by 1991 (T. Buczek – unpubl. data). These data provide confirmation of the fact that the increases observed in the study areas were not merely local in nature.

From among the possible reasons for the increases in the populations of Marsh Harriers observed in Europe, mention is most frequently made of two factors: the limiting of the persecution of birds of prey in many countries (Saurola 1985, Noer & Secher 1990) and the withdrawal from common use in breeding areas of DDT (Cramp & Simmons 1980, Witkowski 1989). The first of these factors leads to reduced mortality among both adults and flying young, while the second increases brood productivity.

Indirect evidence for the decreased role of persecution may be gained from the observation that, of the 654 nestlings ringed by the authors, and the 33% of ringed individuals for which recoveries have been received, only two birds (0.3% of the total) have been noted as shot. In previous decades, Marsh Harriers nesting in central Europe suffered considerably more at the hands of hunters: 44–83% of the recoveries obtained by Haas (1954) and Missbach (1982) referred to ringed birds that had later been shot. A considerable fall in the proportion of recoverig relating to shot birds can also be seen in material from the Ornithological Station in Gdańsk. In the four successive decades between 1950 and 1990, the proportions of Marsh Harriers ringed in Poland and later shot were respectively 5.3% (N = 38 nestlings ringed), 2.7% (N = 37), 1.3% (N = 473) and 0.3% (N = 1957). Where DDT is concerned, Witkowski (1989) has presented data which are indicative of increased breeding productivity of Marsh Harriers in western Poland following the withdrawal of DDT (in 1975). It may be considered that there is currently only a slight threat posed to birds of prey in Polesie Lubelskie by polychlorinated hydrocarbons (Keller *et al.* 1983). The breeding productivity of the Marsh Harriers observed in this area currently is high (T. Buczek & M. Keller – unpubl. data).

These two elements – high breeding productivity and the reduced role of persecution – would be sufficient to explain the increase in the studied population of Marsh Harriers, providing that the young birds do return to the area of their birth. Missbach (1982) has confirmed that at least some birds from this species do nest for the first time within a radius from their birthplaces of a few tens of kilometers. In this study, it was noted that 9 of the 132 harriers which had been wingmarked on the bogs did nest there after 2 years (Buczek in press). There is as yet a lack of data in relation to the mortality of the species at its wintering grounds.

The phenology of laying

Comparisons of data for the onset of laying by Europe's Marsh Harriers do indicate greater variations with latitude than with longitude (Schipper 1979, Witkowski 1989). The modal dates for the onset of laying in eastern Poland are analogous to those given by Witkowski (1989) for western Poland. It is only in relation to the earliest dates that the east was found to differ from the west (with the onset of laying being delayed by about one week).

When analyzing the influence of the course of temperatures in the Netherlands on the onset of laying there by Marsh Harriers (the so-called "effective date"), Schipper (1979) found that the first clutches were laid: (1) after April 9th, (2) if the temperature on two days was not below 4 °C, and (3) if there was a fall of not more than 28% in the temperature on the next 1–2 days. Witkowski (1989) was able to confirm this rule for western Poland, but it must be emphasized that the date of the onset of breeding by the first pairs in a given season is not correlated with either the median date or the length of the period for the onset of laying by the population as a whole. Thus, the rule formulated by Schipper (1979) does not explain the variation in the dates of the onset of breeding noted in the field for different pairs in a given population in a given season. The 6–10 days' noted here for the reaction by birds to the fall and rise of temperature is similar to the value of 5–7 days obtained by Schipper. However, the methods by which these figures were established did differ, and it would seem that greater objectivity and more precise conclusions can be obtained through the analysis based on the cumulative course of temperatures which is proposed in this paper. This is because the method used here relates to all nesting pairs, rather than solely to the single pair which begins breeding at the earliest date.

The literature on birds of prey indicates various proximate factors which may influence the date on which the first egg is laid. The influences of temperature and the amount of precipitation in the pre-breeding period have been demonstrated (by Newton & Marquiss 1984), as has the role of the amount of food (Cave 1968, Drent & Daan 1980, Newton & Marquiss 1981, Village 1985, Beukeboom *et al.* 1988, Meijer *et al.* 1989), and of the age of parents and their individual features (Newton & Marquiss 1984). A question arises concerning the mechanism by which these factors act. It would seem that a number of the relationships determined empirically could be explained by reference to the "body condition hypothesis". This assumes that the condition for the onset of the laying of eggs by a female in a given season is the attainment of the appropriate body condition, which includes an increase in body weight (Poole 1985, Dijkstra *et al.* 1989). This must occur in early spring, when there is still little food, and when birds have already used up at least part of their reserves of fat during the return migration from the wintering grounds. Hypothetically, the factors leading to differentiation in the dates of the onset of laying by individual pairs may include the following: (1) the date of the return from the wintering grounds, (2) the age of the female, and her condition following the return to the breeding grounds, (3) the age and quality of the male which provides the female with extra food in the period prior to laying, and (4) certain additional factors which influence the effectiveness of hunting by the male – including wind and temperature. The roles of only some of these factors have so far been demonstrated (Schipper 1973, Altenburg *et al.* 1982, Rice 1982, Simmons 1988, Meijer *et al.* 1989), and little is yet known about their relative significance.

Fig. 8. has been constructed by adopting the "body condition hypothesis" as a starting point. It contains an attempt to interpret the phenomena observed by the authors in the field. The observed influence of temperature and precipitation in the pre-breeding period on the median dates of the onset of laying may

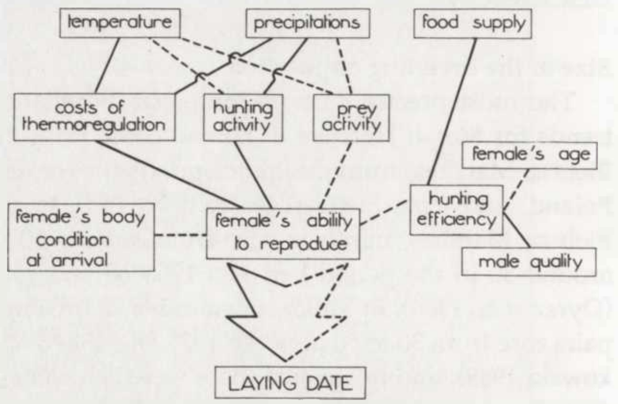

Fig. 8. Schematic representation of the influence of different factors on the date of the onset of laying. Continuous lines mark a proven impact and dotted lines a hypothetical impact.

[Ryc. 8. Schemat wpływu poszczególnych czynników na datę przystępowania do rozrodu. Ciągłymi liniami zaznaczono oddziaływanie udowodnione, liniami przerywanymi – hipotetyczne.]

be accounted for by reference to several mechanisms which are not mutually-exclusive:

– the direct impact on the costs of thermoregulation for the female (mean daily temperatures in the period are often below zero),

– an indirect influence via the effectiveness of hunting by the birds, which in turn depends on: the amount of food, the activeness of the prey, and the age, experience and quality of the birds making up the pair.

There is a lack of data which could allow all the elements in the proposed scheme to be verified and located correctly in some kind of hierarchy. Nevertheless, the greater differentiation between median dates in warm and cold winters, than between "vole" and "non-vole" years is interesting. Likewise, there was little effect on median dates for the onset of laying due to the percentage representation of meadows in the structure of feeding grounds (meadows are the basic habitat for Common Voles). This would seem to attest to the greater significance of the influence of meteorological conditions, at least in comparison to the factor of food. The limited significance of the latter factor may have been influenced by: (1) the limited differences in the numbers of voles in early spring in the different years and different areas (inf. J. Gliwicz), and (2) the ability of harriers to feed on a wide range of prey items (Schipper 1977, Bock 1978, Underhill-Day 1985, Witkowski 1989, Bavoux *et al.* 1990, authors' own data), which compensates for the lack of voles. Dead fish, available as the ice retreats, may certainly have been a substitute food in the conditions provided by retention reservoirs. For the time being there are no strictly empirical materials relating to the remaining factors presented in Fig. 8.

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STRESZCZENIE

[Ekologia rozrodu błotniaka stawowego *Circus aeruginosus* we wschodniej Polsce. Część 1. Liczebność populacji i fenologia przystępowania do rozrodu.]

Ekologię rozrodu błotniaka stawowego badano w dwóch typach środowisk położonych we wschodniej Polsce na Polesiu Lubelskim (ryc. 1). Na zbiornikach retencyjnych Zahajki i Mosty (powierzchnie Z i M) obserwacje prowadzono w latach 1979–1986, a na torfowiskach węglanowych Gotówka, Roskosz i Brzeźno (G, R i B) w latach 1986–1988, 1990 i w niepełnym wymiarze w 1992 roku.

Badania polegały na corocznej ocenie liczebności populacji lęgowej, wyszukiwaniu możliwie dużej liczby gniazd i ich regularnych kontrolach. Obserwacje rozpoczynano od momentu powrotu błotniaków z zimowisk (szczyt przylotów przypadał na ostatnią dekadę III; najwcześniejsza obserwacja – 14 III 1987). Ocena liczebności populacji lęgowej była dokonywana na podstawie znalezionych gniazd (odnaleziono 94% gniazd). Kontrole gniazd rozpoczynano w okresie składania jaj, co umożliwiało dokładne określenie terminu rozpoczynania lęgów (data zniesienia pierwszego jaja). W gniazdach znalezionych podczas inkubacji datę zniesienia pierwszego jaja wyznaczano wstępnie na podstawie testu wodnego (wg własnej skali) i/lub stopnia zabrudzenia jaj. Tak określone daty weryfikowano oznaczając wiek piskląt. Korzystano tu z klucza opartego na pomiarach 5 lotki. Obliczając datę zniesienia jaja przyjęto, że okres inkubacji trwał przeciętnie 33 dni (Witkowski 1989, dane własne). W takich przypadkach data rozpoczęcia lęgów była ustalana z dokładnością do jednej pentady (5 dni). Przy wyznaczaniu dat medialnych przyjmowano dla tych zniesień środkowy dzień pentady. Podczas wysiadywania gniazda były kontrolowane przynajmniej raz w tygodniu. Pozwoliło to prześledzić losy lęgów. W przypadku par, które utraciły zniesienia możliwe więc było zbadanie ich dalszych losów, ewentualne odszukanie lęgów powtarzanych i określenie terminów ich rozpoczęcia. Charakteryzując strukturę żerowisk błotniaków stawowych wokół badanych lęgowisk (tab. 1) arbitralnie, opierając się na dokonanych obserwacjach przyjęto, że ptaki te polowały w promieniu 4 km od gniazda. Analizując wpływ czynników meteorologicznych na fenologię lęgów wykorzystano dane ze Stacji Agrometeorologicznej w Uhrusku leżącej pomiędzy badanymi powierzchniami.

Na wszystkich badanych powierzchniach obserwowano wzrost liczebności par lęgowych. Wynosił on od 17 do 179% w ciągu 5–7 lat (tab. 2). Spowolnienie tego procesu w 1990 roku na powierzchniach G i B było spowodowane wypaleniem znacznych obszarów zajmowanych uprzednio przez błotniaki. Maksymalne zagęszczenia par lęgowych wynosiły 2.6–7.3 par/100 ha (tab. 2). W ostatnich dekadach podobne tendencje liczebności tego gatunku obserwuje się zarówno na terenach Polski jak i w Europie. Spośród możliwych przyczyn tego wzrostu wymieniane są przede wszystkim dwa czynniki: ograniczenie tępienia ptaków drapieżnych w wielu krajach oraz wzrost produktywności populacji tego gatunku po wycofaniu z powszechnego użytku DDT na terenach jego lęgowisk. Materiały Stacji Ornitologicznej Inst. Ekologii PAN w Gdańsku również pokazują, że w ciągu ostatnich dekad nastąpił wyraźny spadek udziału wiadomości powrotnych pochodzących z zastrzelonych błotniaków stawowych. W czterech analizowanych przez autorów tej pracy dziesięcioleciach: lata 50., 60., 70. i 80. udział ptaków zastrzelonych wynosił odpowiednio: 5,3% (N = 38 zaobrączkowanych piskląt), 2,7% (N = 37), 1,3% (N = 473) i 0,3% (N = 1957) w stosunku do liczby zaobrączkowanych w tych okresach na terenie Polski błotniaków stawowych. Najwcześniejsze pierwsze zniesienie zostało zapoczątkowane 14 IV 1990, najpóźniejsze – 18 V 1987 i 1988. Szczyt przystępowania do lęgów przypadał na 26–30 IV (ryc. 2), a data medialna na 29 IV (N = 241 lęgów

pierwszych). Lęgi powtarzane rozpoczynały się pomiędzy 1 a 5 V (N = 16, ryc. 2), najpóźniejszy lęg z tej kategorii rozpoczął się 20 VI 1987 (młode opuściły gniazdo na początku IX).

W poszczególnych latach najwcześniejsze lęgi błotniaków stawowych pojawiały się od 14 IV (1990) do 30 IV (1980, 1982). Szczyt przystępowania do lęgów stwierdzany był najczęściej pomiędzy 26 a 30 IV (ryc. 3). Ostatnie lęgi pierwsze rozpoczynały się w latach "wczesnych" między 1 a 5 V a w latach "późnych" między 16 a 20 V. Porównanie dat przystępowania błotniaków stawowych do lęgów w różnych częściach Europy wykazuje większe zróżnicowanie tej cechy ze względu na szerokość niż długość geograficzną. Modalne terminy przystępowania do rozrodu przez błotniaki stawowe we wschodniej Polsce są analogiczne do dat podawanych dla ptaków gniazdujących w Polsce zachodniej, jedynie daty najwcześniejsze na wschodzie są opóźnione o ok. tydzień. Długość okresu rozpoczynania lęgów przez błotniaki stawowe wynosiła w poszczególnych latach od 15 do 35 dni. Daty medialne w poszczególnych latach istotnie różniły się od siebie. Szukając przyczyn tych różnic przeanalizowano wpływ temperatury (średnie dobowe) i opadów (liczba dni z opadami) w okresie poprzedzającym lęgi na terminy ich rozpoczynania. Analizę przeprowa-dzono w 3 arbitralnie przyjętych wariantach: 1–21 IV, 8–21 IV oraz 15–21 IV (tab. 3, ryc. 4). Współczynnik korelacji wielokrotnej był największy gdy brano pod uwagę temperatury w okresie 8–21 IV oraz opady w okresie 1–21 IV. Porównano również daty medialne przystępowania do rozrodu w latach "mysich", charakteryzujących się szczytami liczebności populacji nornika zwyczajnego *Microtus arvalis* i "nie mysich" (ryc. 5). W latach masowego pojawu norników (1981, 1984, 1987, 1990) błotniaki przystępowały do lęgów istotnie wcześniej (o 3,7 dnia) niż w pozostałych latach.

Jedyną istotną różnicę w terminach przystępowania błotniaków do lęgów wykazano między blisko położonymi od siebie powierzchniami Z i M. Przyczyną tej różnicy jest odmienna struktura żerowisk wokół tych powierzchni (tab. 1). Zaobserwowano, że na powierzchniach o dużym udziale łąk (jako łąki traktowano też zmeliorowane torfowiska) błotniaki gnieździły się wcześniej, nie była to zależność statystycznie istotna (ryc. 6).

Dla 4 lat badań, w których możliwe było wyznaczenie dat zniesienia pierwszego jaja z dokładnością do jednego dnia, zbadano wpływ przebiegu temperatur kwietniowych na rozpoczynanie lęgów. Ponieważ wykresy średnich dobowych temperatur powietrza w tym okresie mają bardzo nieregularny charakter (ryc. 7.1–7.4, wykresy dolne) skonstruowano kumulowane krzywe temperatur dodatnich ("suma ciepła") i porównano je z kumulowanymi krzywymi liczby założonych lęgów (ryc. 7.1–7.4. wykresy górne). We wszystkich 4 sezonach badań zwraca uwagę znaczne podobieństwo kształtu obu krzywych oraz ich duża równoległość. Szczególnie istotne jest, że: (1) zahamowanie przyrostu temperatury powoduje każdorazowo zahamowanie liczby rozpoczynanych zniesień po upływie 6–10 dni oraz (2) wzrost przyrostu temperatury wiąże się z podejmowaniem nowych lęgów po upływie 8–9 dni. Zauważono, że spadkom temperatury powodującym zahamowanie przystępowania do lęgów każdorazowo towarzyszyły opady. Ponadto błotniaki rozpoczynały lęgi w okresie wzrostu temperatur i braku opadów. Ze względu na znaczną zależność między spadkami temperatur a występowaniem opadów trudno jest oddzielić wpływ obydwu tych czynników na fenologię rozrodu błotniaków. Stwierdzony w niniejszej pracy czas reakcji ptaków na spadek i wzrost temperatury dni jest zbliżony do wartości podawanej przez Schippera (1979) 5–7 dni, chociaż sposoby ustalenia tej wartości były różne. Autorzy sądzą, że proponowany sposób analizy przebiegu kumulowanych krzywych temperatur umożliwia większą obiektywność i precyzję wnioskowania, gdyż dotyczy wszystkich gniazdujących par, a nie tylko jednej pary przystępującej do lęgów najwcześniej. Schipper stwierdził, że pierwsze lęgi (*effective date*) błotniaków stawowych w Holandii są zakładane: (1) po 9 IV, (2) jeżeli temperatura podczas 2 kolejnych dni wynosi minimum 4°C, (3) jeżeli spadek temperatury podczas następnych 1–2 dni nie jest większy niż 28%. Witkowski (1989) potwierdził tę zasadę badając błotniaki w zachodniej Polsce. Jednak data rozpoczęcia lęgów przez pierwsze pary w danym sezonie nie koreluje ani z datą medialną ani z długością okresu rozpoczynania lęgów przez całą populację. Zasada sformułowana przez Schippera nie tłumaczy więc obserwowanego w terenie zróżnicowania terminów przystępowania do rozrodu przez poszczególne pary badanej populacji w danym sezonie.

W literaturze poświęconej ptakom drapieżnym podawane są rozmaite czynniki bezpośrednie (*proxi-*

mate factors) wpływające na termin złożenia pierwszego jaja. Udowodniono wpływ temperatury i opadów w okresie przedlęgowym, ilości pokarmu oraz wieku rodziców i ich indywidualnych cech. Powstaje pytanie o mechanizm działania tych czynników. Wydaje się, że wiele stwierdzanych empirycznie zależności mogłaby tłumaczyć "hipoteza kondycyjna" (*body condition hypothesis*). Przyjęto w niej, że warunkiem rozpoczęcia przez samicę składania jaj w danym sezonie jest osiągnięcie przez nią odpowiedniej kondycji, w tym – wzrostu ciężaru ciała. Czynnikami różnicującymi terminy przystępowania do lęgów poszczególnych par mogą być: (1) termin przylotu z zimowisk, (2) wiek i kondycja samicy po przybyciu na tereny lęgowe, (3) wiek i jakość samca dostarczającego samicy dodatkowy pokarm w okresie przed złożeniem jaj oraz (4) niektóre dodatkowe czynniki wpływające na efektywność polowania samców jak np. wiatr i temperatura. Jak dotąd jedynie niektóre z powyższych czynników zostały udowodnione, mało też wiadomo o ich względnym znaczeniu. Przyjmując za punkt wyjścia "hipotezę kondycyjną", skonstruowano diagram (ryc. 8) zawierający próbę interpretacji obserwowanych przez nas w terenie zjawisk. Przedstawiony w niniejszej pracy wpływ temperatury i opadów w okresie przedlęgowym na daty medialne rozpoczynania lęgów można tłumaczyć przez nawzajem niewykluczające się mechanizmy: – bezpośrednie oddziaływanie na koszty termoregulacji samicy (dobowe temperatury minimalne w tym okresie są często niższe od zera), – pośredni wpływ poprzez efektywność polowania ptaków, uzależnioną z kolei od: ilości pokarmu, aktywności ofiary, wieku, doświadczenia i jakości ptaków tworzących parę. Nie dysponujemy danymi pozwalającymi na zweryfikowanie wszystkich elementów zaproponowanego schematu i na ich ewentualne zhierarchizowanie. Interesujące jest jednak większe zróżnicowanie dat medialnych pomiędzy latami o ciepłej i zimnej wiośnie niż pomiędzy latami "mysimi" i "nie mysimi". Podobnie niewielki wpływ na zróżnicowanie medialnych dat przystępowania do lęgów pomiędzy badanymi powierzchnimi miał procentowy udział łąk w strukturze żerowisk (łąki są podstawowym siedliskiem występowania norników). Świadczyłoby to o ważności wpływu warunków meteorologicznych, przynajmniej w stosunku do czynnika pokarmowego. Na małe znaczenie tego ostatniego może wpływać: (1) niewielkie zróżnicowanie liczebności nornika w okresie wczesnowiosennym między latami i między powierzchniami oraz (2) zdolności błotniaków do wykorzystywania szerokiego spektrum ofiar kompensującego brak norników.

Redaktor pracy: prof. Maciej Luniak