

*Barbara BIESIADA-DRZAZGA, Dorota BANASZEWSKA, Katarzyna ANDRASZEK¹,
Elżbieta BOMBIK², Ewa WÓJCIK¹, Dominik OSTROWSKI*

ASSESSMENT OF PEREGRINE FALCON (*PEREGRINE FALCON*) HATCHING IN PRIVATE BREEDING

OCENA LĘGÓW SOKOŁA WĘDROWNEGO (*PEREGRINE FALCON*) W HODOWLI INDYWIDUALNEJ

Department of Breeding Methods and Poultry and Small Ruminant Breeding, University of Natural Sciences and Humanities, Siedlce, Poland

¹ Department of Animal Genetics and Horse Breeding, University of Natural Sciences and Humanities, Siedlce, Poland

² Department of Animal Reproduction and Hygiene, University of Natural Sciences and Humanities, Siedlce, Poland

Streszczenie. Celem pracy była ocena lęgów sokoła wędrownego w wybranym gospodarstwie indywidualnym na terenie województwa mazowieckiego. Badania przeprowadzono w latach 2006–2011 na dwóch parach sokołów wędrownych w wieku 7–12 lat. Od pary hodowlanej podbierano jaja, prowokując ją do ponownego składania jaj. Przeprowadzoną w pracy analizę lęgów oparto na następujących wskaźnikach: liczba zniesionych jaj przez dwie samice w systemie dwóch lęgów w jednym roku, procent zapłodnienia jaj, procent wylęgu piskląt. Ponadto w 2010 roku przeprowadzono porównanie wyników lęgów pochodzących z inkubacji sztucznej i lęgów naturalnych. Samice z obu par w każdym z dwóch lęgów łącznie znosiły maksymalnie do 8 jaj. Lepsze wyniki lęgu uzyskiwano z I lęgu. Z I lęgu uzyskano również większy odsetek wylęgu piskląt z jaj zapłodnionych, w porównaniu z lęgiem II. Nie stwierdzono żadnych różnic pomiędzy wynikami lęgu naturalnego i inkubacji sztucznej. W badanym okresie uzyskano od obu par sokołów łącznie 18 piskląt.

Key words: hatching, peregrine falcon.

Słowa kluczowe: lęgi, sokół wędrowny.

INTRODUCTION

The peregrine falcon was widely but sparsely distributed in Poland at the beginning of the 20th century (Trommer and Wieland 2003). Most birds were observed in the Warmia and Masuria region. After the second world war, around 1950, the population of this species declined drastically partially due to an application of DDT-based plant protection chemicals (Pielowski 1996, Bonczar and Kozik 2006, Sielicki and Sielicki 2009). As a result, in the 1970s, only single individuals of the peregrine falcon were seen nesting in Poland (Tomiałojć 1990).

According to Tomiałojć (1990), the Polish population of this species in the 1980s was no greater than 5 breeding pairs. Such a small population was mainly due to the fact that the mortality of birds up to 12 months of age was estimated to be as much as 60% (Boruc et al. 2013a). When the species was almost extirpated, it was assumed that its survival may be dependent on breeding in captivity. As the Polish tree population was almost extinct, attempts were made to breed peregrine falcons in pens. However, there were no peregrine falcons living in the wild in Poland so birds were obtained from breeding facilities in Western Europe (Brzuski et al. 1999, Sielicki and Sielicki 2009, 2010).

Since the establishment of modern Polish falconry, protection of birds of prey has been one of its key objectives (Zawadzka and Lontkowski 1996). The program for the restitution of the peregrine falcon in Poland, initiated in the 1980s (Fruziński 1985, Pielowski 1985), was introduced ten years later (Wiśniewski 1995). The reintroduction program details both methods and goals (Wiśniewski 1995). Birds used in this program are reared with as little contact with humans as possible (Sielicki and Sielicki 2009). All the falcons reared in Poland are either reintroduced into the wild or add to the breeding stock. Private breeders, who keep and breed peregrine falcons on their farms, participate indirectly in the program, too. The purpose of this work was to evaluate peregrine falcon clutches on a selected private farm located in the Mazovian Province (Voivodeship).

MATERIALS AND METHODS

Studies were conducted on a breeding farm located in the Mazovian Province over the years 2006–2011. Birds were kept in closed pens which complied with the requirements of housing birds of prey. They were fed according to the feeding standards for raptors. Food was provided once daily. If temperatures in winter fell below 0°C, the rate was split and the birds were fed twice daily. Several weeks before the mating season, the birds were fed suitably prepared, sexually mature pigeons. Such feeding continued throughout the whole breeding season, the ration being supplemented with quails and one-day-old cooks. Observations were made of two pairs of peregrine falcons. One pair consisted of a 12-year-old female X and a 7-year-old male X1, the other pair was made up of a 10-year-old female Y and a 7-year-old male Y1. At the end of 2010 male X1 died and was replaced with a 4-year-old male X2. In 2009, the pulling method was used for pair X that is each subsequent egg, after laid, was removed from the nest and placed in an incubator. After mating, females laid eggs which were next placed in an incubator. The incubation incubator electronic BOROTTO RO-22 with adjustable temperature and relative humidity. The temperature during the incubation was maintained at 37.2–37.5°C. The relative humidity in the incubator maintained at 45–50%. In the last 2011 years experimentally reduced relative humidity to 40–45%. The eggs in the incubator were arranged at an angle of about 45°. Turning the eggs in the incubator takes place automatically every 2 hours. The eggs were removed from nests to make each breeding pair re-nest. Regardless of the number of planned clutches (a system of one or two clutches) both females laid eggs every 2 or 3 days. Analysis of clutches presented in this paper was based on the following indicators: number

of eggs laid by two females in a system of two clutches per year, % fertilised eggs, % hatched chicks. Moreover, in 2010, results of natural and artificially incubated clutches (the second clutch of pair Y) were compared. Statistical differences between the samples were tested using Fisher's Exact Test.

RESULTS

Figure 1 demonstrates numbers of eggs laid by both the females in the years 2006–2011. In 2006, pens with the birds were moved to a new site. As a result of the stress, the females laid no eggs in 2006. The maximum number of eggs per hatching laid by the females in a two-clutch system was eight. Although female Y laid only 1 egg in 2007, the number increased to 7–8 eggs in the following years. Throughout the study period, the female laid 31 eggs, which was by 3 eggs more than female X.

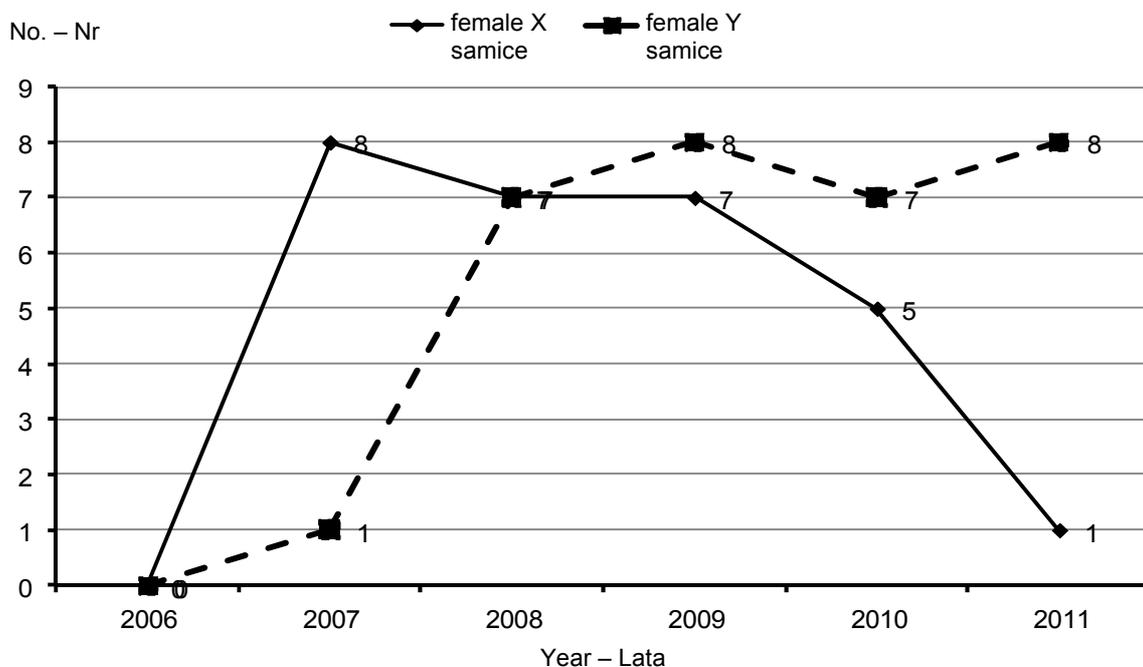


Fig. 1. Eggs laid by females X and Y within 6 years (2006–2011)
Rys. 1. Liczba jaj zniesionych przez samice X i Y w ciągu 6 lat (2006–2011)

Reproduction results for each pair of the falcons are shown in Table 1. The data revealed that even when a female laid a maximum possible number of eggs, not all of them were fertilised, which resulted in a small number of chicks. Such situation was observed in 2007, when female X laid 8 eggs but only 3 of them were fertilised and only 2 chicks hatched. In turn, in 2009 female Y laid 8 eggs 7 of which were fertilised but only 1 chick was obtained. In 2009, the pulling method was used for pair X that is each subsequent egg, after laid, was removed from the nest and placed in an incubator.

Table 1. Breeding results of the peregrine falcon pairs
 Tabela 1. Wyniki reprodukcyjne badanych par sokołów wędrownych

Year Rok	Pair Para	Number Liczba								
		the eggs laid jaj zniesionych		the eggs set jaj nałożonych		the fertilised eggs jaj zapłodnionych		the chicks that hatched out jaj wyklutych		
		Clutches Legi								
		I	II	I	II	I	II	I	II	
2006	X	–	–	–	–	–	–	–	–	–
	Y	–	–	–	–	–	–	–	–	–
2007	X	4	4	4	4	3	0	2	0	
	Y	1	0	1	0	1	0	0	0	
2008	X	4	3	4	3	4	1	1	1	
	Y	4	3	4	3	3	0	2	0	
2009	X	7		7		6		3		
	Y	4	4	4	4	4	3	1	0	
2010	X	3	2	3	2	3	2	1	0	
	Y	3	4	3	4	3	4	1	2	
2011	X	1	–	0	–	0	–	0	–	
	Y	4	4	4	4	4	2	3	1	

The procedure had no negative impact on the reproduction results of the pair, as indicated by the number of fertilised eggs (6) compared with the number of eggs laid (7). In 2011, female X was paired with a new male, which resulted in disrupted egg production. In the breeding season 2011, young male X2 did not perform a typical courtship display, did not display call and was not interested in the female, which resulted in no eggs laid. In 2011, as an experiment, the relative humidity in the incubator was lowered to the level of about 5% compared with the previous years. The lower humidity had a positive effect on chicks that hatched. All the chicks were healthy at hatching and with no yolk sac, unlike the preceding years when incubation was carried out at constant humidity.

Table 2 presents hatching results for both the pairs of falcons. The data demonstrates that better results were obtained for clutch 1. The percentage of fertilised eggs in this clutch was 100 in as many as 5 cases. What is more, clutch 1 had a higher percentage of chicks hatched from fertilised eggs, compared with clutch 2. However, in one case no chicks hatched despite 100% viability (pair Y in 2007).

Table 3 contains reproduction results of pair Y in clutch 2 which were used to compare artificial incubation and natural hatching in 2010. Female Y laid 4 eggs in clutch 2. Two eggs were left in the nest and the other two were removed for artificial incubation. No differences were found between the results of artificial and natural incubation. In both cases two eggs were viable and 1 chick hatched per female. However, when eggs are incubated in a natural manner, they are more likely to be damaged or underheated.

Table 2. Hatching results of the peregrine falcon pairs
Tabela 2. Wyniki wylęgu sokołów wędrownych (%)

Year Rok	Pair Para	Fertilised eggs Jaja zapłodnione		Chicks hatched from eggs set Wylęg piskląt z jaj nałożonych		Chicks hatched from fertilised eggs Wylęg piskląt z jaj zapłodnionych	
		Clutches Lęgi					
		I	II	I	II	I	II
2006	X	–	–	–	–	–	–
	Y	–	–	–	–	–	–
2007	X	75	0	50	0	66.7	0
	Y	100	0	0	0	0	0
2008	X	100	33.3	25	33.3	25	100
	Y	75	0	50	0	66,7	0
2009	X	85.7		42.9		50	
	Y	100	75	25	0	25	0
2010	X	100	100	33.3	0	33.3	0
	Y	100	100	33.3	50	33.3	50
2011	X	0	–	0	–	0	–
	Y	100	100	75	25	75	50

Table 3. Comparison of hatching results of artificial and natural incubation in 2010

Tabela 3. Zestawienie wyników reprodukcyjnych II lęgu porównujących inkubację sztuczną z naturalną prowadzoną w 2010 roku

Pair Para	Kind of incubation Rodzaj inkubacji	Number of eggs laid Liczba jaj zniesionych	Number of eggs set Liczba jaj nałożonych	Number of fertilised eggs Liczba jaj zapłodnionych	Number of chicks that hatched out Liczba jaj wyklułych
Female Y and male Y1 Samica Y z samcem Y1	artificial incubation <u>inkubacja sztuczna</u> natural hatching lęgi naturalne	4	2	2	1
			2	2	1

DISCUSSION

The peregrine falcon is a late maturing species (Mebs 1998). Sexual maturity in females and males occurs in the second and third year of life, respectively. Sexually mature birds change their plumage and their legs, cere and eyering become more intensely coloured. Pairing depends on an initial acceptance by both the partners although it is believed that it is the female that chooses a male (Brzuski et al. 1999). Peregrine falcons usually mate for life (Trommer and Wieland 2003). The mating season begins when birds display courtship behaviour (Boruc et al. 2013b). Eggs are laid from the second decade of March to mid-April. The females in the study discussed here laid eggs from 26 March to 1 May, depending on the year. Non-viable eggs are a very frequent problem of captive breeding, particularly for young birds (Brzuski et al. 1999). In this study 15 out of 58 eggs laid were non-fertilised. According to Brzuski et al. (1999), better laying performance can be obtained by improving the birds' condition by e.g.: improving nutrition, supplementing food with vitamins, changing location of their ledges or insemination which, however, can be very stressful for birds. In the wild,

the female usually lays 2 to 4 non-glossy creamy-white eggs with red and brown markings (Indykiewicz 2000). Eggs are laid at 1–3-day intervals (Brzuski et al. 1999). In this study, the greatest number of eggs per clutch was 4 and they were laid at the rate mentioned in the available literature (every 2–3 days). Successful breeding performance depends, among others, on the appropriate incubation of eggs laid. One breeding pair in captivity can produce 6 to 8 eggs or even more. When birds are provoked to re-nest, it is possible to obtain more chicks of peregrine falcons bred in captivity (Weaver and Cade 1991). Although both sexes participate in incubation, females typically spend more time incubating than males. Males replace females for short periods of time, usually after bringing food (Brzuski et al. 1999). Observations of the birds presented in this paper suggest that the above-mentioned behaviour is instinctive and the conditions under which falcons are kept do not have any impact on it. In the study discussed, the birds examined never left the nest unattended although it was safe in the pen. Other researchers have reported similar findings and concluded that, after several years in captivity when birds do not have enough space to fly freely, are fed regularly, and suffer no stress caused by the presence of man, get used to such conditions, which can only slightly affect the birds' behaviour during incubation (Payne 1972, Cieślak and Kwieciński 2005, 2009). Moreover, studies carried out on birds in captivity so far have demonstrated that their behaviour is quite similar to wild birds (Forsman 1980, Pyle 1997, Cieślak and Kwieciński 2009).

During a given laying cycle, falcons begin to incubate their eggs after the penultimate or last egg has been laid. After about 7–10 days of natural incubation, eggs are removed from the nest and placed in an incubator (Sielicki and Sielicki 2009). Initial natural incubation has been demonstrated to have a marked impact on egg hatchability. When natural incubation is reduced to three or four days, egg hatchability ranges from 50 to 60 %. It increases to 75–85% when natural incubation is extended to five-ten days (Burnham et al. 1984). There are many factors affecting incubation, e.g.: time, quality of care in case of natural incubation, how often eggs are turned and ventilated, weather conditions, type of nest or birds' physical condition (Deeming 2002, Kwieciński et al. 2009). According to Deeming (2002), frequency of egg rotation depends on incubation length, egg weight and, in particular, albumen content (the higher the structural albumen/remaining components ratio an egg has, the more frequently it is rotated). The temperature in an incubator is the most important factor as it is very easy to overheat eggs (when temperature rises rapidly). Overheating is much more critical than short-term underheating. (Grant 1982, Haftron 1984, Webb 1987, Conway and Martin 2000). The temperature in the incubator should range from 36 to 38°C and relative humidity should be 40%. The relative humidity in the hatcher can vary between 55 and 60% (Weaver and Cade 1991). Hatching usually begins after 32 to 34 days of incubation when chicks start to pip the shell. They are then kept for about 12–14 days and next transferred to the nest, after the second clutch eggs have been removed. In this way the brooding instinct is replaced by the parental care instinct. Juvenile falcons may be reintroduced after about 40 days (Brzuski et al. 1999).

CONCLUSIONS

There were no marked differences between the numbers of eggs laid and fertilised between the two pairs of falcons. A total of 18 chicks were obtained from both the pairs through the study period. The results of the present study may constitute the basis for making further observations of reproduction elements and incubation behaviour of the peregrine falcon and can be used in comparisons of this kind of studies carried out in nature.

REFERENCES

- Bonczar Z., Kozik B.** 2006. Podsumowanie programu restytucji sokoła wędrownego *Falco peregrinus* w Pieninach [Review of peregrine falcon *Falco peregrinus* reinstatement programme in the Pieniny]. Pieniny – Przyr. Człow. 9, 121–128. [in Polish]
- Boruc K., Łukasiewicz M., Wnuk A., Siennicka A.** 2013a. Skrzydlaty przyjaciel – chów i hodowla sokoła wędrownego (*Falco peregrinus*). Cz. I [Winged friend – Animal breeding peregrine falcon (*Falco peregrinus*)]. Part. I. Pol. Drob. 7, 20–22. [in Polish]
- Boruc K., Łukasiewicz M., Wnuk A., Siennicka A.** 2013b. Skrzydlaty przyjaciel – chów i hodowla sokoła wędrownego (*Falco peregrinus*). Cz. II [Winged friend – Animal breeding peregrine falcon (*Falco peregrinus*)]. Part II. Pol. Drob. 8, 50–51. [in Polish]
- Brzuski P., Bonczar Z., Pinkowski M., Kalchreuter H.** 1999. Restytucja sokoła wędrownego w Polsce. Warszawa, Pol. Zw. Łow.
- Burnham W.A., Enderson J.H., Boardman T.J.** 1984. Variation in peregrine falcon eggs. The Auk 101, 578–83.
- Cieślak M., Kwieciński Z.** 2005. Pierzenie sów jarzębatych *Surnia ulula* w Poznańskim Ogrodzie Zoologicznym [Moult *Surnia ulula* in Poznan zoo]. Not Orn. 46, 143–157. [in Polish]
- Cieślak M., Kwieciński Z.** 2009. Moulting and breeding of captive Northern Hawk Owls *Surnia ulula*. Groningen The Netherlands Ardea 97(4), 571–579.
- Conway C.J., Martin T.E.** 2000. Effects of ambient temperature on avian incubation behavior. Behav. Ecol. 11, 178–188.
- Deeming C.D.** 2002. Avian incubation. Oxford, Oxford University Press.
- Forsman D.** 1980. Ageing and moult in Western Palearctic Hawk Owls *Surnia u. Ulula* L. Orn. Fenn. 57, 173–175.
- Fruziński B.** 1985. Znaczenie soloknictwa w Polsce dla ochrony przyrody i łowiectwa. Aktywna ochrona ptaków drapieżnych i sokolnictwo. Włocławek, ZG PZŁ, 42–43.
- Grant G.S.** 1982. Avian incubation. Egg temperature, nest humidity and behavioral thermoregulation in hot environment. Orn. Monogr. 30, 1–75.
- Haftron S.** 1984. The behaviour of an incubating coal tit *Parus ater* in relation to environmental regulation of nest temperature. Fauna Norveg. 7, 12–20.
- Indykiewicz P.** 2000. Ptaki drapieżne Borów Tucholskich. Ekologia i ochrona. Bydgoszcz, AT-R.
- Kwieciński Z., Krawczyk A., Ćwiertnia P.** 2009. Wpływ temperatury otoczenia na wybrane elementy behawioru inkubacyjnego orła przedniego *Aquila chrysaetos* w warunkach wolierowych [Influence of ambient temperature on selected elements of the incubation behavior of the golden eagle *Aquila chrysaetos* in aviary conditions]. Notat. Ornitol. 50, 1–8. [in Polish]
- Mebis T.** 1998. Ptaki drapieżne Europy. Warszawa, Multico.
- Payne R.B.** 1972. Mechanisms and control of moults. Avian. Biol. 2, 103–155.
- Pielowski Z.** 1985. Hodowla wolierowa ptaków drapieżnych w aspekcie restytucji rzadkich gatunków. Aktywna ochrona ptaków drapieżnych i sokolnictwo. Włocławek, ZG PZŁ, 81–87.
- Pielowski Z.** 1996. Ptaki drapieżne. Warszawa, Wydaw. Świat, 256.

- Pyle P.** 1997. Flight-feather moult patterns and age in North American Owls. Monogr. Field Ornithol. 2.
- Sielicki S., Sielicki J.** 2009. Populacja nadrzewna sokoła wędrownego *Falco peregrinus* w Europie i restytucja gatunku w Polsce [Arboreal population of peregrine falcon *Falco peregrinus* in Europe and the restoration of the species in Poland]. Stud. Mater. Centr. Eduk. Przyr.-Leś. II, 3(22), 67–85. [in. Polish]
- Sielicki S., Sielicki J.** 2010. Restytucja sokoła wędrownego *Falco peregrinus* w Polsce a fundusze unijne [Restitution peregrine falcon *Falco peregrinus* in Poland and EU funds]. Stud. Mater. CEPL Rogów 12, 2(25), 191–219. [in Polish]
- Tomiałojć L.** 1990. Awifauna Polski, rozmieszczenie i liczebność. Warszawa, PWN.
- Trommer G., Wieland P.** 2003. Sokół wędrowny w Polsce. Wymarcie i odrodzenie gatunku. Leszno, MANUS.
- Weaver J.D., Cade T.J.** 1991. Falcon propagation. Boise Idaho, The Peregrine Fund Inc. 99.
- Weeb D.R.** 1987. Thermal tolerance of avian embryos: A review. Condor 89, 874–898.
- Wiśniewski G.** 1995. Programme for the reinstatement of the Peregrin Falcon in Poland. Acta Ornithol. 30(1), 73–78.
- Zawadzka D., Lontkowski J.** 1996. Ptaki drapieżne. Dlaczego chronimy. Warszawa, Agencja Rekl.-Wydaw. A. Grzegorzczak.

Abstract. The purpose of this work was to evaluate peregrine falcon clutches on a selected private farm located in the Mazovian Province (Voivodeship). Studies were conducted on a breeding farm located in the Mazovian Province over the years 2006–2011. Observations were made of two pairs of peregrine falcons. The eggs were removed from nests to make each breeding pair re-nest. Analysis of clutches presented in this paper was based on the following indicators: number of eggs laid by two females in a system of two clutches per year, % fertilised eggs, % hatched chicks. Moreover, in 2010, results of natural and artificially incubated clutches (the second clutch of pair Y) were compared. The maximum number of eggs per hatching laid by the females in a two-clutch system was eight. The better results were obtained for clutch 1. What is more, clutch 1 had a higher percentage of chicks hatched from fertilised eggs, compared with clutch 2. No differences were found between the results of artificial and natural incubation. A total of 18 chicks were obtained from both the pairs through the study period.