

Time Budget, Organochlorines and Productivity in the Peregrine Falcon *Falco peregrinus* in the Kolyma Lowlands Region (North-Eastern Siberia)

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ABSTRACT

The Peregrine Falcon was studied in Lower Kolyma, Siberia (1982-1991). Eggshell thickness and time budgets were measured. The thin shell of Siberian Peregrine eggs indicates that the population may have been contaminated by organochlorines. The actual levels of the DDE vary from 6.19 ppm wet weight (181.80 ppm in lipid) in one site to 22.06 ± 2.86 ($n = 4$) ppm dry weight (383.8 ± 21.93 ($n = 4$) ppm in lipid) in three sites. There is no significant difference in eggshell thickness between clutches with different fates. Eggs with thick shells may be eaten by the female; on the other hand chicks may hatch from eggs with very thin shells. That suggests that thin eggshells are not the only reason for low reproductive success in the Lower Kolyma.

The duration of male and female hunts was recorded. The duration of single hunts by males dramatically decreased in nests with higher reproductive success. In unsuccessful nests the duration of the hunt could be up to 23 hours. There is a significant difference in the duration of male and female hunts. The time spent hunting by females is less than by males and does not vary significantly with reproductive success. When the brood size is larger than average, both parents may increase their hunting efforts.

MATERIAL AND METHODS

Observations were made in three study areas: in 1982-1983 in the Chukochya river basin (168km²); in 1985 in the Kolyma river basin (40km²); in 1986-1991 in the Konkovaya river basin (1190.22km²). All study areas are located in the Kolyma Lowlands in the typical tundra subzone. All Peregrine Falcons' nests were found (Table 1) in the study areas, checked regularly, and their reproductive success recorded. Eggshell fragments were collected from the nest-sites and their thickness measured with callipers with an accuracy of 0.002mm. Infertile eggs were collected and blown and their eggshell index or Ratcliffe index (Ratcliffe 1980) (weight of shell (mg) divided by length x breadth) estimated. For the eggs collected in 1991 the organochlorine concentrations were measured using gas-liquid chromatography. The analyses were made at the Monks Wood

Experimental station, Institute of Terrestrial Ecology. The organochlorine concentration was measured in five eggs from four clutches.

Measurements of the time budgets were made from a hide located not less than 200m from the nest. Both parents were observed with binoculars and telescopes, and all their movements and activities during not less than 24 hours were recorded. Special attention was paid to the measurement of the duration of a hunting sortie, which proved to be a good parameter for comparing the time budget of pairs with various reproductive success. The duration of a hunting sortie is defined as the time spent by a bird hunting away from a nesting cliff. In total, 15 full daytime budgets from 10 sites were obtained.

RESULTS

The total number of pairs and productivity of Peregrine Falcon is shown in Table 1. The reproductive success was very low (see also Fig. 1).

Table 1. Reproductive success of Peregrine Falcons in Lower Kolyma.

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Number of pairs under observation	2	3	2	3	4	4	5	6	6	7	8
clutches	2	2	0	0	4	4	5	4	4	7	7
Number of eggs	7	7	0	0	15	16	16	16	15	24	18
Number of chicks hatched	7	0	0	0	3	3	6	6	14	16	13
Number of chicks fledged	?	0	0	0	3	3	2	2	6	13(?)	13
Reproductive success (fledglings per pair)	?	0	0	0	0.75	0.75	0.4	0.3	1	1.86	1.63

The causes of mortality are shown in Figure 2. Besides the ordinary causes such as infertility and accidents (a cliff fall), the most important were cannibalism (chicks eaten by parents) and egg-eating. Only two out of 83 eggs from 23 clutches were recorded as broken. However, most commonly eggs just disappeared. I suggest that the parents ate them. This was observed directly on one occasion, and beak marks on the shell on three other occasions suggested that these eggs were also eaten.

Apparent egg-eating tended to occur in nests where the adults spent long periods hunting. Many chicks also died after hatching. During the first stages of their development the most likely reason for their death was being eaten by their parents. At older stages, some starved to death on the cliff being unable to climb back into their nest. The highest causes of mortality were egg-eating (40.35%) chick-eating (22.81%), infertile eggs (19.30%) and accidents (14.4%). The number of survivors declined steadily through the summer (Figure 3). Both chicks and eggs declined at the same rate during a season; out of 23 clutches (83 eggs) under intensive observation only 31.3% of chicks fledged.

As there is no human population in the region, the likely mortality factors affecting the population are the contamination of adults elsewhere and lack of prey availability.

Figure 4 shows the eggshell thickness with standard deviation measured in different clutches plotted against the number of nestlings. Zero means that the clutch was eaten. The thin shell of Siberian Peregrine eggs indicates that the falcon population has been contaminated by organochlorines similar to British Peregrines in the 1960s (Ratcliffe 1980). The actual levels of pesticides are shown in Table 2.

Table 2. Pesticide levels in Peregrine eggs.

SITE	HCL	HCB	HEOD	DDE	PCBs	Mercury
1	0.01(0.24)	0.02(0.34)	0.07(1.53)	18.47(381.15)	0.83(17.19)	0.33
2	0.13(2.23)	0.01(0.21)	0.07(1.13)	22.16(362.55)	0.41(6.58)	1.35
5	0.03(0.47)	0.06(0.94)	0.04(0.62)	22.44(400.96)	1.48(23.28)	1.20
7	0.01(0.31)	0.03(0.76)	0.08(2.38)	6.19(181.80)	0.29(8.43)	2.79

Comment: HCL is a derivative of lindane; HCB is hexachlorobenzene; HEOD is a derivative from aldrin & dieldrin; DDE is a derivative from DDT; PCBs are polychlorinated biphenyls. Concentration is given in ppm wet weight, figures in brackets are concentrations in lipid.

Figure 1. Reproductive success of Peregrines in the Lower Kolyma region.

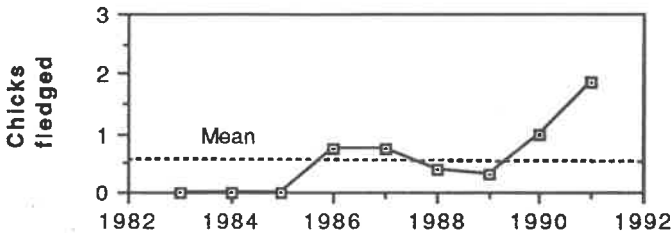


Figure 2A. Causes of mortality in the Peregrine Falcon in the Lower Kolyma region.

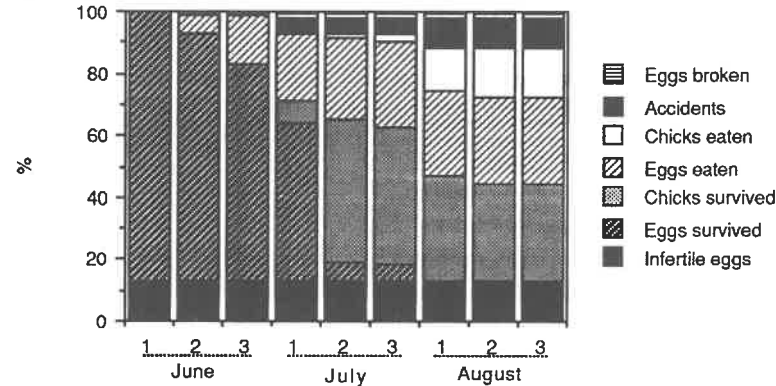


Figure 2B. Mortality/survival of Peregrine Falcons in the Lower Kolyma region.

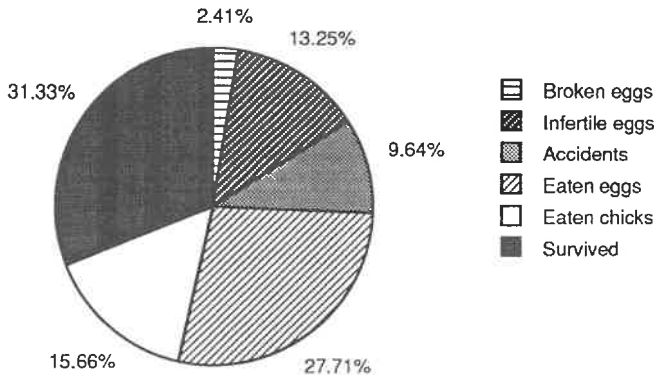


Figure 3. Number of survivors during a summer.

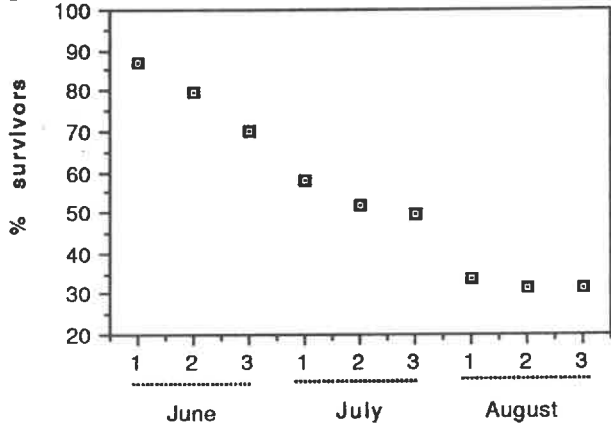


Figure 4. Eggshell thickness in clutches with different fates.

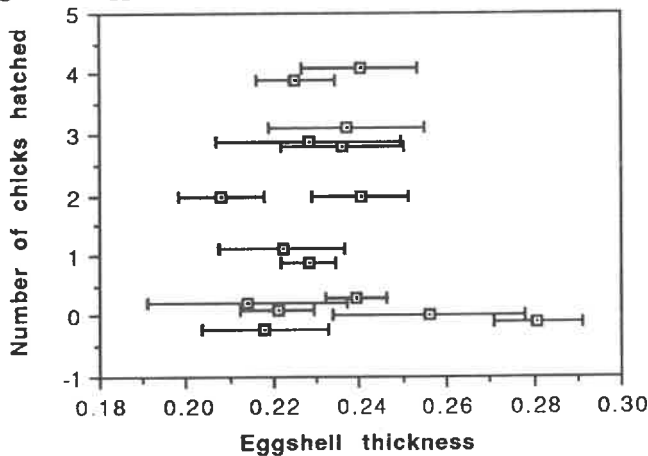


Figure 5. Daily time budget of Peregrines in the Kolyma Lowlands.

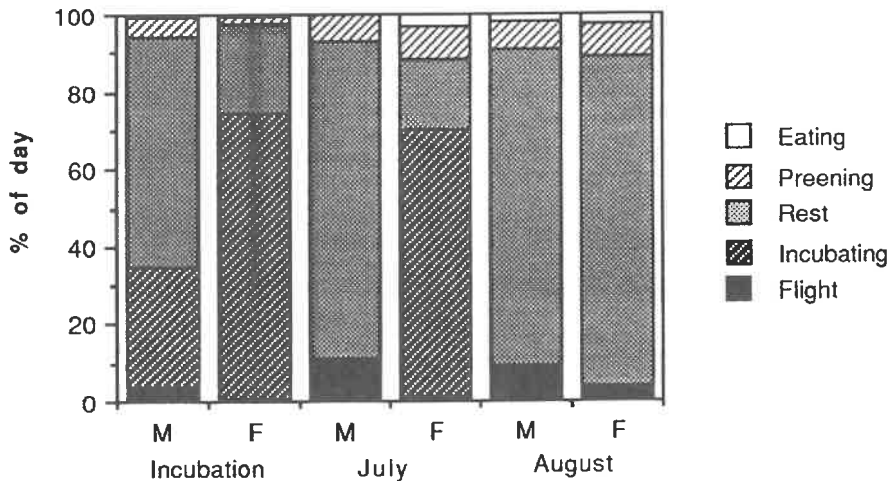


Figure 6A. Reproductive success and duration of a single hunt, Lower Kolyma.

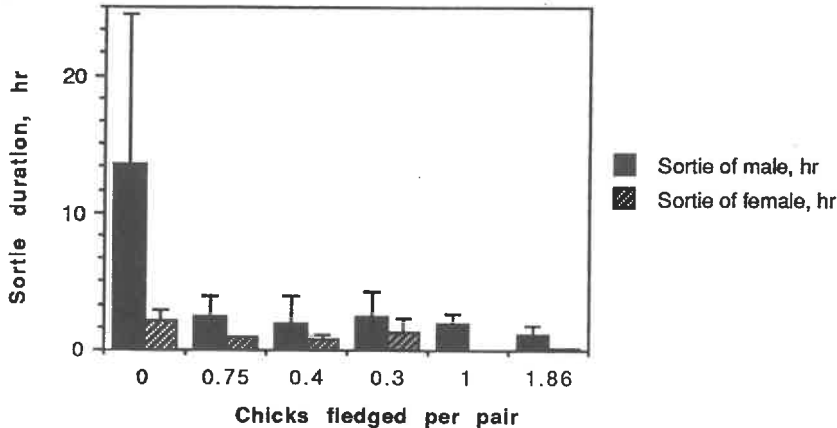


Figure 6B. Duration of a single hunt, Lower Kolyma.

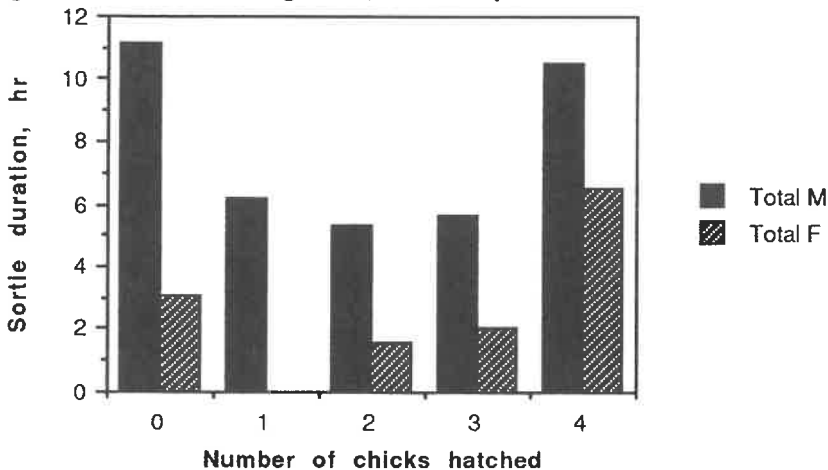
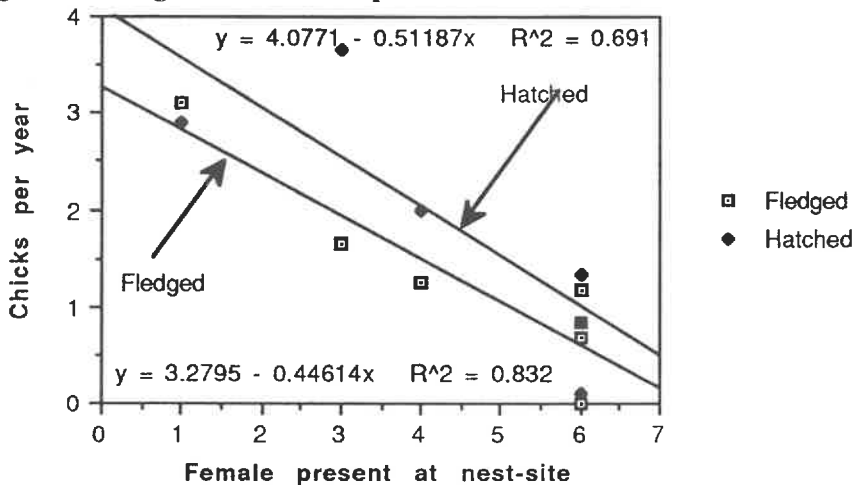


Figure 7. Average number of chicks produced at nest-sites under observation.



The pesticide levels in the Peregrine eggs may be one of the reasons for low reproductive success. They are known to be the main reason for eggshell thinning in raptors. However, Figure 4 shows that there is no significant difference in eggshell thickness in clutches with different fates. Eggs with very thick shells may be eaten by the female, but on the other hand chicks may hatch from eggs with very thin shells.

The daily time budgets of Peregrines in the Kolyma Lowlands are given in Figure 5. Both parents spend the overwhelming proportion of their time resting or incubating/brooding. These activities have low energy costs (Dol'nik 1982). Flight is an activity of high energy cost, and birds may fly up to 2 hours 43 minutes/day; however, they can significantly reduce the cost by soaring whenever possible. Use of soaring is subject to weather conditions, but can reach up to 40% of the total time spent flying. There is a difference between male and female time budgets. Males tend to spend more time flying, while females spend a larger proportion of their time incubating/brooding.

The time spent by both parents in flight can be divided into time spent in hunting, in mobbing gulls and skuas and in short flights when the bird changes its position on a cliff. The proportion of time spent in hunting is higher in males than in females and its significance to a family is obvious. Duration of hunting sorties shows a strong correspondence with the reproductive success. Figure 6 represents data on the durations of hunting sorties plotted against numbers of chicks eventually fledged from their nests. The male's hunting period is the most variable parameter in the time budget. The duration of a single hunt by a male is significantly lower in nests with the highest reproductive success. In unsuccessful nests the duration of the hunt could be up to 23 hours. In fact, if the male spends more than 7 hours in a single hunt either the clutch or the nestlings will be eaten by the female.

There is a significant difference in the duration of male and female hunts. The time spent hunting by females is less than in males and does not vary significantly with reproductive success. The female seems to have short and constant periods of hunting, and her hunting is not usually connected with transporting prey to the nest. The average duration is 1 hour 13 minutes ($n=21$), and varies from a few minutes up to 4 hours.

When the brood size is larger than average, both male and female may increase their hunting efforts (Fig. 6). In a case when the pair had 4 chicks (Fig. 6b, right column) both parents had to increase their hunting time. The hunt duration became longer than 7 hours, and eventually the chicks' remains were recovered in the parents' pellets.

The average productivity calculated for the whole period a female was present at a site plotted against the period of her presence is given in Figure 7. This shows that older females tend to produce fewer chicks than younger newcomers to the area. This may be a result of the accumulation of DDT in adults which could affect the parents' hunting success. That is why the correlation coefficient in the regression between the age of a female and her final productivity is higher than that between the number of hatchlings and the female's age.

DISCUSSION

It is well known that organochlorines accumulate in plants and animals, severely affecting animals in the upper end of food chains. The Peregrine Falcon seems to be the species most affected (Cade *et al.* 1968; Cade *et al.* 1988; Ratcliffe 1980; Newton 1979), and in major parts of the world organochlorines were blamed as a main reason for the Peregrine's low reproductive success and survival rate.

Porter & Jenkins (1988) measured eggshell thickness in Peregrine Falcon eggs in California and found a non-significant positive correlation between productivity and eggshell thickness. Fyfe *et al.* (1988) studied the influence of eggshell thickness on the productivity of nests in Merlins and Prairie Falcons in Alberta and showed that in their case eggshell thinning had no bearing on productivity. The data presented in Figure 4 show that eggshell thinning cannot be the only reason for low productivity of the population studied since there was only one recorded case when DDE contamination was a possible direct reason for clutch loss (in 1991 a female was found dead on her eggs, which showed a high concentration of DDE, 3 out of 4 eggs containing embryos). Obviously DDT contamination cannot be a direct reason for mortality in chicks (Fig. 3).

The likely explanation of the low productivity of this Peregrine population in the Kolyma Lowlands region would be that either the organochlorine pesticides accumulate in the adults and somehow reduce their hunting abilities or the unstable and unpredictable availability of food makes it difficult for the parents to feed chicks. The hypothesis of DDT accumulation can be backed by the fact that older females have lower productivity than younger newcomers to the area (Fig. 7). The correlation coefficient is higher in the regression between the number of chicks fledged and the duration of females' presence at a site, than between the number of chicks hatched and the duration of female presence. Therefore the parents' ability to feed a brood limits productivity more than DDE level in eggs.

The question of where the Peregrines pick up the contamination remains unclear. There are two possible ways. The first is via a food chain in the tundra. This is possible because the wading birds which form the main item of the Peregrine's diet spend their winter in regions where the application of DDT may occur. Another possibility is that the Peregrines themselves pick up the contamination during winter, perhaps in South-east Asia or China. However, both may occur together.

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REFERENCES

- CADE, T., C. WHITE & J. HAUGH 1968. Peregrines and pesticides in Alaska. *Condor* 70: 170-8.
- CADE, T., J. ENDERSON, C. THELANDER & C. WHITE (Eds.) 1988. *Peregrine Falcon Populations*. The Peregrine Fund, Inc.
- DOL'NIK, V.R. 1982. Methods of time and energy budget study. *Time and energy budgets of free-living birds* (V.R. Dol'nik, - (Ed.) *Acad. Sci. USSR. Proc. Zool. Inst.* 113:1-156.
- FYFE, R., R. RISEBROUGH, J. MONK, W. JARMAN, D. ANDERSON, L. KIEFF, J. LINCER, I. NISBET, W. WALKER II & B. WALTON 1988. DDE, Productivity and Eggshell thickness relationships in the genus *Falco*. In: T. Cade, J. Enderson, C. Thelander & C. White (Eds.) *Peregrine Falcon Populations*. The Peregrine Fund, Inc.: 319-335.
- NEWTON, I. 1979. *Population Ecology of Raptors*. T. & A. Poyser.
- PORTER, R. & M. JENKINS 1988. Pollutants and eggshell thinning in Peregrines and their prey in the Baja California region. In: T. Cade, J. Enderson, C. Thelander & C. White (Eds.) *Peregrine Falcon Populations*. The Peregrine Fund, Inc.: 413-21.
- RATCLIFFE, D. 1980. *The Peregrine Falcon*. T. & A. Poyser.

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