Shell Thinning in Eggs of Ungava Peregrines

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Breeding populations of the Peregrine Falcon (*Falco peregrinus*) disappeared from many areas of North America during the period between 1950 and the early sixties (Hickey, 1969) but Peregrines have continued to persist in apparently normal numbers in northern Canada and in Alaska (Enderson and Berger, 1968; Enderson *et al.*, 1968; Cade *et al.*, 1968). In Britain, California, and the eastern United States Peregrine eggs collected during the period of the decline were subsequently found to be thin-shelled (Ratcliffe, 1967; Hickey and Anderson, 1968). In this paper we report on shell thinning observed in Peregrine eggs obtained from the Ungava region of northern Quebec and adjacent islands of the Northwest Territories in 1967 and 1970.

During July and August of 1967, under contract with the Canadian Wildlife Service, D. D. Berger and J. D. Weaver located fifteen eyries in Ungava. The objectives of this expedition were to obtain fat biopsy samples from breeding females and to collect a limited number of eggs for analysis of pollutants suspected to be the cause of the extinction process afflicting the Peregrine.

In 1970, also under contract with the Canadian Wildlife Service, D. D. Berger and R. W. Risebrough revisited some of these sites and located additional eyries while participating in a survey of breeding Peregrines in Arctic Canada (Cade and Fyfe, 1970). Data on reproductive success of five other Peregrine eyries in Ungava in 1970 and samples of addled and broken eggs have kindly been provided by Robert B. Berry and J. Peter Jenny, Jr. and their observations are incorporated into the present paper.

Fat was biopsied from nine females in 1967, of which four were from sites where eggs were also taken. Biopsy techniques have been described previously (Enderson and Berger, 1968). The fat samples and contents of the eggs collected were preserved in 10% formalin solution and were analysed by L. M. Reynolds. Analytical techniques for DDE were those described in Vermeer and Reynolds (1970).

Twelve eggs were obtained in 1967 and nine in 1970. Of these only one was fresh and viable when collected. Of the other 20, a clutch of four was abandoned when found with no adult in the vicinity, two eggs were broken with the contents removed, six were cracked and contained dead embryos, three were addled with no embryonic development, four were addled with dead mature embryos and one was addled with an early embryo. The egg sampling was therefore biased towards those eggs that were abandoned, addled, broken, or cracked.

Ten of the eggs collected in 1967 were analysed for the DDT compound p,p'-DDE' (DDE). The average concentrations were 12.7 ± 8.7 parts per million of the wet weight contents of the egg and 253 ± 160 ppm of the lipid material in the yolk and embryo (95% confidence limits of the standard error of the mean). The fat biopsy samples contained 310 ± 87 parts per million of DDE on a wet weight basis or 334 ± 95 ppm in the lipids. The egg residues are therefore comparable to those in two eggs collected in Alaska in 1966 that averaged 12.5 ppm on a wet weight basis and 285 ppm in the lipids (Cade *et al.*, 1968) and to those in five viable eggs from the Mackenzie River in 1966 that contained 17.8 ± 10.9 ppm wet weight (Enderson and Berger, 1968). The amounts of DDE in adult fat are comparable to the average concentration of 392 ppm in the lipid recorded in nine samples from the Mackenzie River in 1966 (Enderson and Berger, 1968), but are lower than an average concentration of 725 ppm in the lipid of four adult female Peregrines from Alaska (Cade *et al.*, 1968). Enderson *et al.* (1968) have reported that the total concentrations of organochlorine compounds of insecticide origin, of which DDE is the most abundant, in the fat of four adult female Peregrines on the Yukon River in 1967 were 130, 717, 754 and 2435 parts per million. The level of DDE contamination in the Ungava Peregrines is therefore equivalent to or somewhat lower than the levels existing in Peregrine populations elsewhere in the Arctic. 42 recent Peregrine eggs from those areas in Great Britain where the Peregrine has experienced reproductive failures correlated with shell thinning and egg breakage contained an average concentration of 13.7 ppm of DDE in the fresh weight contents (Ratcliffe, 1970). DDE constituted 90% of all organochlorine compounds of insecticide origin in the eggs. The DDE concentrations in the eggs of the Ungava Peregrines are therefore virtually the same as the concentrations recorded in the eggs of the British birds.

The temporal midpoint of our census in 1967 was July 16, approximately 5 days after the peak of the hatch. It might therefore be expected that the observed clutch and/or brood size would be slightly less than the mean clutch size of 3.0 reported by Hickey (1942) for Arctic North America, 2.9 for northern Alaska, and 3.1 for other Arctic localities (Cade, 1960). We found a mean of 2.67 eggs and/or young for the 15 eyries in 1967, including two sites occupied by subadult females. One of these had two eggs, and the other was tending an empty scrape. Four of the eyries contained 4 eggs and/or young, suggesting that checks made soon after laying is completed would reveal that clutches of 4 are more common than was previously supposed. The 1970 census was carried out in late July and early August, too late to obtain clutch size data.

Eggshell thickness was measured as described by Anderson and Hickey (1970). When more than one egg was taken from a clutch, the measurements within the clutch were averaged so that only one thickness value is presented per clutch. Fifty nine Peregrine eggs collected in the eastern Arctic between 1900 and 1940 and preserved in museums were measured to determine the shell thickness of eggs laid before the widespread introduction of the DDT compounds and other persistent pollutants into the environment and before changes in mean shell thickness of museum eggs can be detected. The mean thickness of the 59 museum eggs, which were treated individually rather than on a clutch basis was 0.369 ± 0.017 mm (95% confidence limits of the standard error of the mean). Thickness of the 21 recent eggs from twelve clutches was 0.291 ± 0.013 mm. The average reduction in shell thickness was therefore 21%. Because of the sample bias towards broken and cracked eggs, the mean thickness of eggs producing young might be somewhat greater. The shell thickness of the single viable egg and the mean thickness of the four abandoned eggs were 0.29 and 0.288 mm respectively. The two broken eggs averaged 0.275 mm (0.25 and 0.30 mm), the addled eggs with no embryonic development 0.310 mm (0.28, 0.32 and 0.33), the cracked eggs with dead embryos 0.290 mm (0.27 - 0.30 mm) and the single addled egg with an early embryo had a shell thicknes of 0.30. There is therefore a tendency for the addled eggs showing no embryonic development to be somewhat thicker-shelled than the average, but all eggs showed approximately the same degree of thinning at a level that is sufficient to increase the probability of breakage. The eight eggs that were broken or cracked were collected at five eyries, four of which had one downy young and the fifth had two. The five addled eggs containing dead embryos were found at three sites. The presence of one or more downy young at each of these eyries reduces the probability that mortality resulted from adverse weather or from disturbance. It is not clear, however, whether the mortality can be attributed to the thinning of the eggshell.

Twenty three young and seventeen eggs were found in the fifteen eyries located in 1967. Of the eggs two were of undetermined status but were probably addled. Three were of a clutch from which the single fertile egg was collected, but the remaining two eggs disappeared during incubation. All other eggs were broken, cracked addled or abandoned. Eleven pairs were successful in hatching young and the average brood size of downy chicks per successful pair was therefore between 2.1 and 2.3. The average brood size per successful eyrie on the Colville River was 2.7 ($N = 21$) in 1952 and was 2.3 ($N = 19$) in 1959 (Cade, 1960).

In 1970 twelve occupied sites were visited between July 25 and August 15. Of these only seven were successful, and the mean brood size per successful pair was 1.7. The average number of young per occupied site dropped to 1.0 from 1.5 in 1967.

Our data are not sufficient to permit a conclusion about the overall current reproduction of the Ungava Peregrines since it would be necessary to visit each site several times spanning the breeding season from the return of the adults in the spring to the fledging of the young in order to determine the reproductive success per active eyrie. They indicate, nevertheless, that the population has reached a critical level of shell thinning resulting in the production of broken or cracked eggs and lower than normal numbers of young hatched. The reproductive rate, therefore, may not be sufficient to maintain the stability of the population.

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