Thickness of the American Woodcock Eggshell, 1971

by J. F. KREITZER
United States Department of the Interior
Bureau of Sport Fisheries and Wildlife
Patuxent Wildlife Research Center, Laurel, Md. 20810

INTRODUCTION

Birds of a number of species have produced eggs with abnormally thin eggshells in association with a population decline both here (HICKEY and ANDERSON 1968, BLUS 1970) and abroad (RATCLIFFE 1967). A similar pattern of reproductive failure also occurred in captive species fed DDE (WIEMEYER and PORTER 1970, HEATH et al. 1969, LONGCORE et al. 1971, McLANE and HALL 1972) or a mixture of DDT and dieldrin (PORTER and WIEMEYER 1969).

This paper reports the shell thickness of eggs of the American woodcock (Philohela minor) in 1971 in comparison with the shell thickness of eggs collected during the period from 1859-1939. This study was undertaken to help evaluate the status of the United States woodcock population following closure of the hunting season in New Brunswick because of DDT residues in woodcock tissues (Canadian Government Communiqué 1-7078. 1970).

METHODS

From one to four eggs or empty shells (n = 117) were collected in 1971 from each of 73 nests in 10 states. Shells were air dried at about 70°F for 7 days; thickness of shell (plus shell membranes and chorion and amnion) was measured at the waist with a starrett 1010M dial gage calibrated in 0.01 mm units. The chorion and amnion in shells from which chicks had hatched could not be separated from the shell membranes hence their inclusion in the measurement could not be avoided.

Seven of the 1971 eggs contained fully developed embryos, 26 contained no embryos (to the unaided eye), and 84 had hatched.

Eggshells (n = 322) from a number of museums, collected from 89 nests in 16 states from 1859 through 1939, were measured for comparison. Collectors' notes for 211 of these shells indicated that 169 had been incubated for no more than one-third of the normal period. Only these were used in thickness comparisons.

Bulletin of Environmental Contamination & Toxicology,
Vol. 9, No. 5 © 1973 by Springer-Verlag New York Inc.

TABLE 1

Shell thickness of woodcock eggs related to state of origin

State	1859-1939			1971		
	Incubation	Eggs/Clutches	Clutch Mean (mm)	Incubation	Eggs/Clutches	Clutch Mean (mm)
Connecticut	≤1/3	4/1	0.155	HA	1/1	.140
	>1/3	4/1	0.163			
	UC	12/3	0.155			
Georgia	UC	4/1	0.163	--	--	--
Indiana	UC	3/1	0.153	--	--	--
Iowa	UC	7/2	0.162	--	--	--
Maine	≤1/3	23/6	0.160	HA	4/2	.149
	UC	8/2	0.161	UE	10/5	.163
				FE	2/2	.155
Maryland	≤1/3	12/3	0.159	FE	1/1	.150
	>1/3	4/1	0.158			
	UC	8/2	0.160			
Massachusetts	≤1/3	4/1	0.163	HA	4/1	.158
	UC	6/2	0.166			
Michigan	≤1/3	9/4	0.165	HA	27/15	.150
	>1/3	3/1	0.160	UE	13/9	.165
	UC	7/2	0.154	FE	2/2	.148

TABLE 1. (Continued)

Minnesota	UC	1/1	0.170	HA	27/12	0.152
				UE	2/1	0.158
New Jersey	UC	23/6	0.170	HA	1/1	0.145
				UE	1/1	0.160
				FE	1/1	0.150
New York	≤1/3	30/8	0.163	--	--	--
	>1/3	11/3	0.157			
	UC	2/1	0.160			
North Carolina	≤1/3	4/1	0.153	--	--	--
	>1/3	4/1	0.165			
	UC	8/3	0.155			
Ohio	≤1/3	61/16	0.164	--	--	--
	>1/3	16/4	0.163			
	UC	22/6	0.162			
Pennsylvania	≤1/3	12/3	0.164	FE	1/1	0.155
Texas	≤1/3	3/1	0.160	--	--	--
Vermont	--	--	--	HA	5/5	0.157
Virginia	≤1/3	7/2	0.174	--	--	--
Wisconsin	--	--	--	HA	15/13	0.157

TABLE 1. (Continued)

Total	322/89	117/73
Extremes	0.140-0.190	0.130-0.170

HA = hatched
UE = unembryonated (to the unaided eye)
FE = fully developed embryo
>1/3 = incubated more than 1/3 normal period
<1/3 = incubated 1/3 or less normal period
UC = unspecified by collector

TABLE 2

Shell thickness of woodcock eggs related to stage of development

Year	Eggs/Clutches	Stage of Incubation[1]	Clutch Mean (mm)	SD	% Difference
1859-1939	169/46	$\leq 1/3$	0.162	0.0065	--
1971	26/16	UE[2]	0.163	0.0074	+0.6[4]
1971	91/57	HA[3]	0.152	0.0096	-6.2[5]

[1] Symbols as in Table 1.
[2] To the unaided eye.
[3] Seven eggs containing fully developed embryos were considered as hatched.
[4] Non significant.
[5] Significant, $P<0.001$.

RESULTS AND DISCUSSION

The mean thickness by state, year, stage of incubation and clutch for all eggshells is given in Table 1. For a valid comparison of the thickness of the 1971 shells vs. the 1859-1939 shells, clutch means of both groups must be segregated by stage of incubation because of the thinning effect of embryonation. That such an effect occurs has been shown in eggshells of Japanese quail which thinned 7.3 percent during incubation (KREITZER 1972), presumably because of the transfer of calcium from the shell to the chick's skeleton. In chickens the amount of calcium thus transferred has been estimated to be about 5 percent of the shell weight (SIMKISS 1967). This transfer occurs in all birds, but it is possible that the percentage loss of calcium or change in thickness differs among species. VANDERSTOEP and RICHARDS (1969) found that chicken eggshells measured after removal of membranes by hydroxide became 6.4 percent (approximated from the authors' graph) thinner during incubation.

A comparison (between means of clutch means) by year and stage of incubation (Table 2) indicates that the 91 shells from eggs that hatched or contained fully developed embryos in 1971 were 6.3 percent thinner ($P<0.001$, analysis of variance) than either the 169 museum shells which had not been incubated more than one-third the normal period or the 26 shells from the unembryonated eggs collected in 1971. The criterion (one-third) was selected, because, in the chicken, little or no calcium has moved from the shell before the 11th day of incubation (VANDERSTOEP and RICHARDS 1969). In woodcock one-third of the incubation period (21 days, BENT 1927) is 7 days, giving a margin for error of 4 days.

Thickness measurements of the 84 hatched shells were biased because of the presence of the chorion and amnion. The thickness of these membranes could not be determined with certainty because of numerous foldings and other irregularities. Relatively smooth fragments, however, measured about 0.01 mm. The mean of these shells plus the 7 containing fully developed embryos becomes 0.146 mm when recomputed with allowance (minus) for this value and is then 9.9% smaller than the mean of the museum shells from essentially unincubated eggs or of the shells from unembryonated 1971 eggs. This thinning is greater than that of the Japanese quail and the chicken, cited above, and may be an adaptation arising from the difficulty of opening an eggshell with a flexible bill. Rather than cutting an operculum from the obtuse end of the egg, the woodcock chick rips open the shell longitudinally by pressure from the cervical and thoracic vertebrae (WETHERBEE and BARTLETT 1962).

It is concluded that in the United States the thickness of the 1971 woodcock eggshell is normal. The observed thinning in the shells from hatched or almost hatched eggs, about 10%, is almost certainly due to transfer of calcium from the shell to the skeleton of the chick and not to environmental pollutants.

SUMMARY

Eggs or empty shells of the American woodcock were collected from 10 states in 1971 and shell thickness (mean of clutch means) was compared with that of eggs collected from 16 states during the years 1859-1939. The 1971 shells (n = 91) from hatched eggs or those containing fully developed embryos were about 10 percent thinner ($P<0.001$) than both unembryonated shells (n = 26) from the same year and the 1859-1939 shells (n = 169) from essentially unembryonated eggs. The difference is attributed to the transfer of calcium from the shells to the embryos and not to environmental pollutants.

REFERENCES

BENT, A. C.: U. S. Nat. Mus. Bull. 142, 61 (1927).
BLUS, L. J.: BioScience 20, 867 (1970).
HEATH, R. G., J. W. SPANN, and J. F. KREITZER: Nature 224, 47 (1969).
HICKEY, J. J., and D. W. ANDERSON: Science 162, 271 (1968).
KREITZER, J. F.: Poultry Sci. (In press).
LONGCORE, J. R., F. B. SAMSON, and T. W. WHITTENDALE, JR.: Bull Env. Cont. and Toxicol. 6, 485 (1971).
McLANE, M. A. R., and L. C. HALL: Bull. Env. Cont. and Toxicol. 8, 65 (1972).
PORTER, R. D., and S. N. WIEMEYER: Science 165, 199 (1969).
RATCLIFFE, D. A.: Nature 215, 208 (1967).
SIMKISS, K.: Calcium in reproductive physiology. New York: Reinhold (1967).
VANDERSTOEP, J., and J. F. RICHARDS: Poultry Sci. 49, 276 (1969).
WETHERBEE, D. K., and L. M. BARTLETT: Auk 79, 117 (1962).
WIEMEYER, S. N., and R. D. PORTER: Nature 227, 737 (1970).