COMPARISON OF SHELL THICKNESS IN WILD AND CAPTIVE PRAIRIE FALCONS

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A study of variations in shell thicknesses among eggs of captive and wild Priaire Falcons (*Falco mexicanus*) was undertaken in order to quantify the relationship between embryo viability and shell thickness and also to determine the extent to which artificial environments may be affecting these two parameters. Shell thickness was considered to be a reliable indicator of eggshell quality inasmuch as shell thickness is directly related to the eggshell's ability to: (1) protect the embryo from external pressures; (2) regulate the rate of exchange of H_2O, O_2, and CO_2; and (3) provide a barrier to invading bacterial and mycotic microorganisms (Romanoff and Romanoff 1949, Simkiss 1967).

A total of 43 eggshells was obtained from seven healthy falcons in the captive breeding projects at the University of Missouri and Cornell University, and another 27 eggshells were collected from 27 eyries in Colorado, Wyoming, and Nebraska. Except for the two eggs identified as P-L-11 and P-SB-12, all eggshells from wild falcons were analyzed for DDE residues and found to contain less than 2 ppm (wet basis) of this compound; thus DDE-induced shell thinning would be undetectable. The "wild" shells should therefore be fairly representative of a normal healthy population of wild Prairie Falcons.

Sections measured were taken from the equatorial region of each shell since this region is characteristically the most uniform portion of the shell (Tyler and Geake 1961). Shells were soaked in water to loosen the allantoic membrane and the membrane was then mechanically removed from the sections so that shell thickness could be accurately measured. Each equatorial shell section was subsequently measured at five sites with an Ames (Waltham, Massachusetts) eggshell micrometer. The mean shell thickness (x) and the corresponding standard deviation (σ) for each egg are presented in Tables 1 and 2.

Eggs were grouped according to the history of the respective falcon (i.e. wild or captive) and were further subgrouped according to the embryonic history of the egg. Eggs which were either infertile or which suffered embryonic mortality within the first two weeks of incubation were considered together inasmuch as embryonic utilization of shell calcium does not take place during the early phases of incubation (Johnston and Comar 1955). Thus shell thickness for the eggs in this group should not have been affected by the presence or absence of a developing embryo.

The second major subgrouping includes all those eggs in which the embryo went full term. Shells in this group should have undergone some thinning inasmuch as the shell is the primary source of calcium for the embryonic skeletal system (Romanoff 1972).

The remaining eggs, i.e. those in which the embryo survived more than two weeks but did not go the full term, represent the third subgroup. These eggs should exhibit some degree of embryo-induced shell thinning, but the extent to which this is so is not known. Therefore, the seven eggs in this subgroup were not considered in the ensuing analysis and are presented only for completeness.

Figurds 1 and 2 represent 41 eggs which were laid by seven captive falcons. In Figure 1 is seen the distribution in shell thicknesses (x = 274.6μ) of 21 hatched eggs from four captive falcons. Figure 2 depicts the corresponding distribution in shell thicknesses (x = 277.9μ) for 20 eggs which were either infertile or

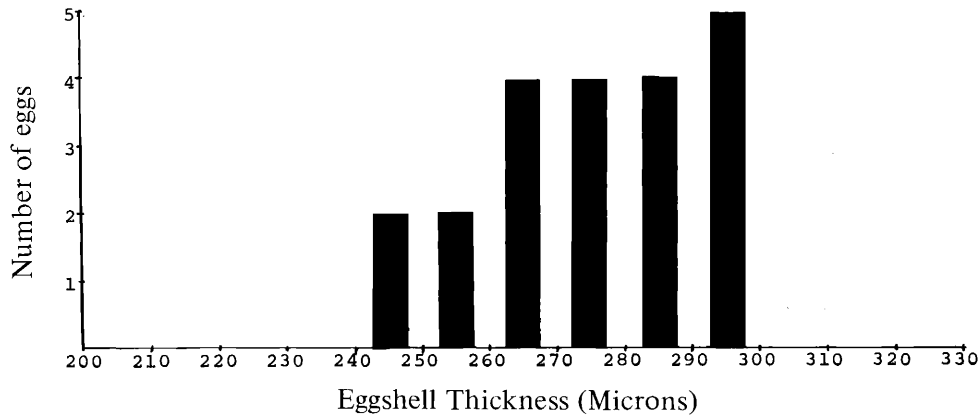

Figure 1. Eggs in which embryo went full term (captive falcons).

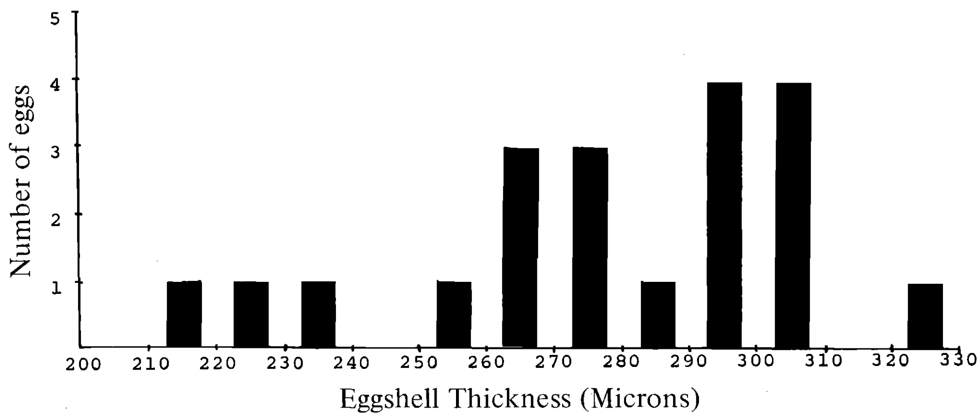

Figure 2. Eggs in which embryo lived less than two weeks (captive falcons).

in which embryo mortality occurred within the first two weeks of incubation. These 20 eggs were collected from five captive falcons.

Figures 3 and 4 are based on 22 eggs from 22 different wild falcon nest sites. The mean shell thickness for the 10 hatched eggs from 10 wild falcons is x = 299.1μ, whereas the mean thickness for the 12 infertile or "early embryonic death" eggs is x = 256.6μ.

A summation of the captive- and wild-hatched eggs is seen in Figure 5. Thirty-one eggs from 14 falcons are represented. Mean shell thickness for all hatched eggs is x = 282.5μ. Figure 6 is a similar grouping of the eggs presented in Figures 2 and 4. The mean shell thickness for these 32 eggs from 17 captive and wild falcons is x = 269.9μ.

An analysis of variance indicates no significant difference in shell thicknesses for the two captive populations (i.e. hatched vs. infertile or early embryonic

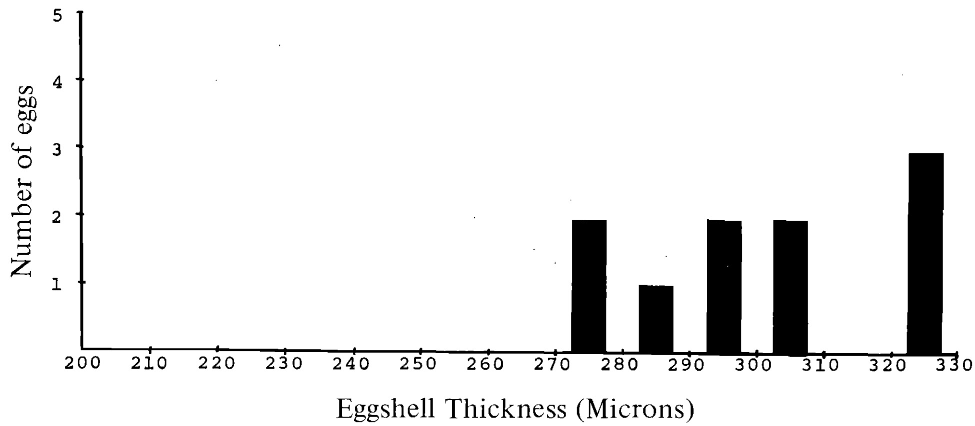

Figure 3. Eggs in which embryo went full term (wild falcons).

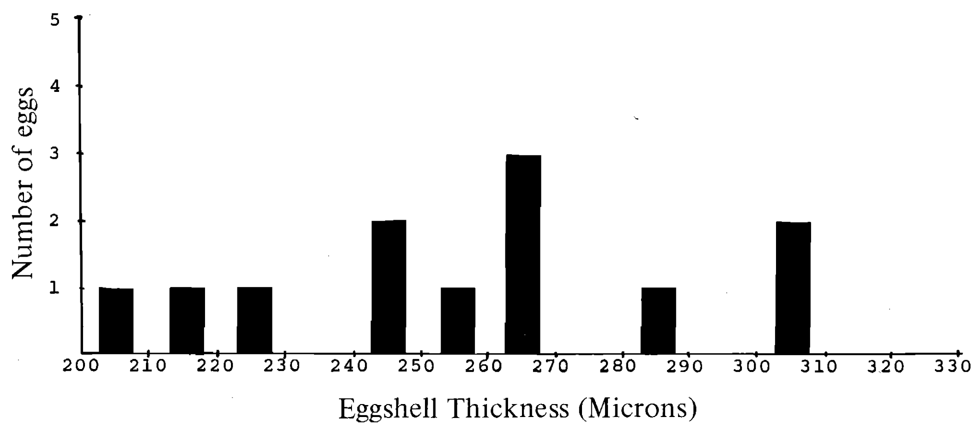

Figure 4. Eggs in which embryo lived less than two weeks (wild falcons).

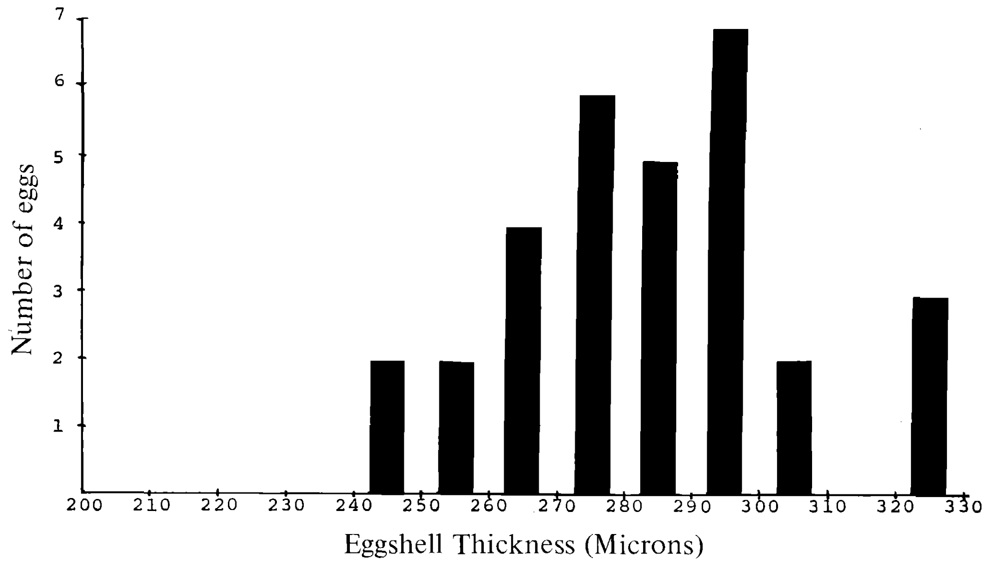

Figure 5. Eggs in which embryo went full term (captive and wild falcons).

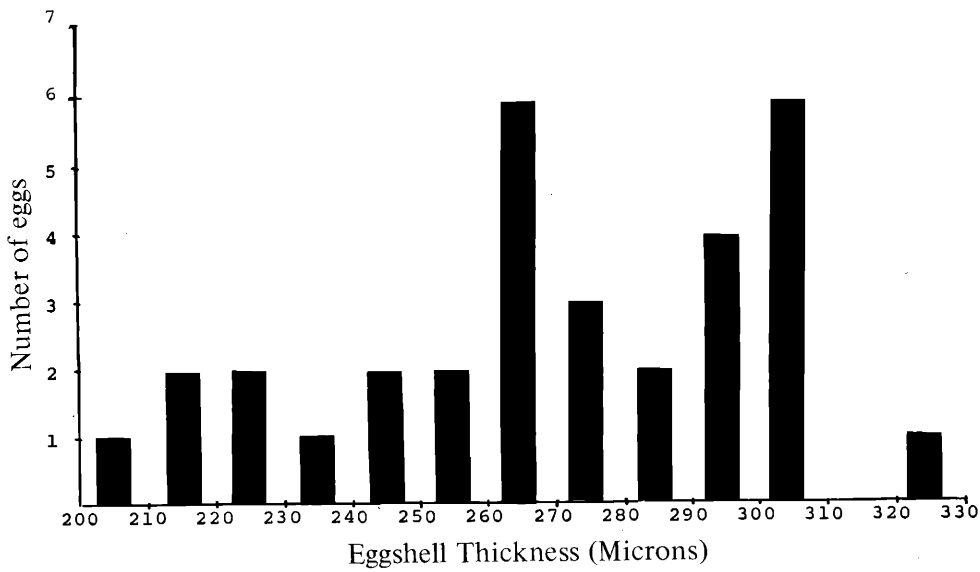

Figure 6. Eggs in which embryo lived less than two weeks (captive and wild falcons.

Table 1. Eggs laid by captive Prairie Falcons.

Egg ID No.	x(μ)*	σ(μ)**	History
D-5-73	248	5.1	eyas died at pip
P-2-7-74	248	2.5	eyas fledged
D-6-73	250	27.6	eyas fledged
P-1-3-74	255	5.5	eyas died from Pseudomonas infection
D-3-73	260	16.6	eyas killed by parents
P-2-9-74	266	3.7	eyas fledged
P-2-8-74	267	5.1	eyas fledged
P-2-6-74	268	5.1	eyas fledged
D-1-3-74	270	7.1	eyas died at pip
W-S-1-5	272	5.1	eyas fledged
D-1-73	277	5.5	eyas died
D-1-1-74	278	4.9	eyas died from Pseudomonas infection
P-1-5-74	283	5.1	eyas died from Pseudomonas infection
D-2-6-74	284	10.1	eyas died at pip
P-1-1-74	287	4.0	eyas died from Pseudomonas infection
W-S-1-3	287	4.0	eyas fledged
P-1-4-74	290	11.4	eyas died from Pseudomonas infection
W-LC-PF-1	292	5.1	eyas fledged
W-S-1-2	294	8.6	eyas died at pip
W-S-2-4	295	5.9	eyas fledged
P-1-2-74	295	7.7	eyas died from Pseudomonas infection
D-2-5-74	262	6.8	embryo died during 4th week
D-2-2-74	271	3.7	embryo died during 3rd week
W-SH-1-2	219	17.4	infertile
W-CPF-1-4B	223	14.4	infertile
W-SH-1-1	239	11.6	infertile
D-9-72	255	5.5	infertile
D-10-72	262	14.4	infertile
D-8-72	263	10.3	infertile
D-2-73	265	12.3	embryo died during 1st week
W-CPF-1-2	271	6.6	infertile
W-SG-1-1	273	4.0	infertile
W-CPF-2	274	5.8	infertile
D-2-3-74	286	5.8	embryo died during 2nd week
D-2-1-74	290	8.3	infertile
W-SG-1-2	291	10.0	infertile
W-CPF-1-1	295	6.3	infertile
W-SG-1-3	295	12.2	infertile
W-CPF-1-3B	305	13.8	infertile
D-7-72	307	14.4	infertile
W-S-1-1	308	13.6	embryo died during 2nd week

Table 1. (continued)

Egg ID No.	x(μ)*	σ(μ)**	History
D-4-73	308	21.2	infertile
W-S-1-4	329	9.7	embryo died during 2nd week

*x(μ) = mean shell thickness (5 sites) at equator.
**σ(μ) = standard deviation.

Table 2. Eggs laid by wild Prairie Falcons.

Egg ID No.	x(μ)*	σ(μ)**	History
E-GW-1	276	13.9	eyas hatched
E-AR	278	13.2	eyas hatched
E-CN	281	12.1	eyas hatched
E-LT	294	10.5	eyas hatched
E-C	295	18.2	eyas hatched
E-SC	300	10.6	eyas hatched
E-L	302	18.3	eyas hatched
E-SSC	320	9.2	eyas hatched
E-NL	320	9.9	eyas hatched
E-OR	325	7.8	eyas hatched
E-T	213	2.4	embryo died during 4th week
E-TN	227	8.1	embryo died during 4th week
E-WR	229	12.6	embryo died during 4th week
E-GW-2	237	5.1	embryo died during 3rd week
E-F	270	7.8	embryo died during 4th week
P-L-11	209	8.0	infertile
P-SB-12	211	6.6	infertile
E-PF-8	223	9.2	infertile
E-PF-6	240	5.5	infertile
E-PF-1	249	3.7	infertile
E-PF-11	254	3.7	infertile
E-PF-12	264	8.0	infertile
E-PF-10	269	3.7	infertile
E-PF-3	269	6.6	infertile
E-PF-2	281	5.8	infertile
E-PF-5	305	6.3	infertile
E-PF-4	305	8.9	infertile

*x(μ) = mean shell thickness (5 sites) at equator.
**σ(μ) = standard deviation.

death) but does indicate a significant difference ($P < .01$) in the shell thicknesses for the two analogous wild populations. The unsuccessful eggs in the wild and captive populations exhibit similar shell thickness distributions, whereas the wild-hatched eggs have significantly thicker ($P < .01$) shells than do the captive-hatched eggs. Considering the fact that all captive eggs were placed in an artificial incubator, whereas the wild eggs were incubated by the respective falcons, it is not surprising to find that the wild egg requires a thicker, stronger shell to withstand successfully the trauma of natural incubation. In conclusion, we have found no manifestation of thinning due to nutritional deficiency in the shells of captive Prairie Falcon eggs.

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