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SHELL DAMAGE IN MECHANICAL EGG GATHERING SYSTEMS-- A CALIFORNIA STUDY

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Mechanical egg collection is becoming more popular due to increased interest in multi-deck high-density housing, which makes hand collection difficult or impossible. This study was undertaken with the following objectives: 1) to determine the amount of breakage occurring during mechanical egg collection; 2) to develop a technique for evaluation of mechanical egg collection systems; and 3) to evaluate mechanical egg handling systems for commercial egg producers in California in order to make ranch managers aware of any unrecognized problems.

RANCH FACILITIES AND PRACTICES

Sixteen ranches and 26 flocks of different ages were surveyed. Seven ranches were located in the southern part of the state (San Bernardino, Riverside, and San Diego Counties), five ranches in the Central Valley (San Joaquin, Stanislaus, and Merced Counties), and four in the North and South Bay area (Sonoma and Santa Clara Counties). Fifteen of the ranches surveyed had LTC houses. Three-fourths of the LTC houses had deep-pit facilities. Negative ventilation systems were predominant with exhaust fans at the bird level and/or in the pit.

A wide variety of mechanical egg gathering equipment was found throughout the state (table 1). Even though similar equipment was used on several ranches, the installation, repair, maintenance and operation of equipment varied considerably.

On most farms the workers walked through the lay house prior to the first gathering each morning looking for dead birds obstructing the roll-out trays and for equipment in need of repair. This procedure usually took up to one hour to complete. On several ranches this was repeated before the second collection. Gathering frequency ranged from once a day to continuous, depending upon the capacity of the gathering and packing equipment in relation to the number of eggs to be gathered. More frequent gathering resulted in fewer eggs on the belts at any one time, lessening the possibility of collision checks. Egg gathering usually started about 8 a.m. and was completed by 4 p.m.; however, there was considerable variation among ranches. All ranches gathered eggs six or seven days per week.

Table 1. Manufacturers of egg gathering systems surveyed

Cage arrangement	Number of ranches
Flat-deck (including wall-to-wall)	
Hart	3
Big Dutchman	3
Ranch design	2
Woody	1
Stair-step	
Hart	3
Diamond	2
Triple-deck	
Big Dutchman	1
Ranch design	1
Total	16

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There were many combinations of washing and packing equipment. Seven systems did not have egg washers (table 2); the eggs were washed at a later time in processing plants. Eight ranches washed their eggs at the ranch and again at the processing plant. This practice helped to insure cleaner eggs but also necessitated the eggs being put through a washer a second time. One ranch gathered, washed, and packed eggs daily in an in-line system. The obvious advantage of this arrangement was the elimination of one handling. Three ranches had people hand-packing eggs into flats from a collection table at the end of the system.

Table 2. Equipment at surveyed ranches

Equipment	Number of ranches
Washers:	
Seymour	7
Featherlite	1
Kuhl	1
None	7
Total	16
Packers:	
Egg-O-Matic	5
Page-Detroit	5
Wyland	1
Vacuum lift	2
Hand-packed	3
Total	16

SURVEY PROCEDURE

A team of Cooperative Extension personnel located ranches with mechanical collection systems and arranged to spend a day at each to collect the necessary data. A simple hand-drawn outline of the egg gathering system enabled the team members to decide beforehand on the various locations within the system that should be observed for egg breakage. On the day of the survey the team arrived one hour before egg gathering began. Egg samples, consisting of 20 flats each (600 eggs), were collected at the following intervals: 1) Directly from the cage tray before or as the system was started in the morning and again at the time of the second collection, and, 2) at the end of the system from egg flats shortly after the system was started for the first and second collection.

All of these samples were hand-candled to identify the number and type of checks present. Checks were classified as either 1) smashed, 2) line, 3) collision, 4) wire or 5) toe.

To determine the place within the system where breakage was occurring, the sample collected from the cage tray in the morning was used for a step-by-step analysis of the system. During this procedure all of the checked eggs except the leakers were numbered and returned to the sample. This procedure provided a method to measure further damage to these checked eggs (i.e., an egg might change from a "line" to a "smashed"). The number and location of sample points within a system varied from one to six depending upon the complexity of the system (figure 1). An attempt was made to sample whenever eggs changed direction or were subjected to handling by equipment (elevator, accumulator, washer, packer, etc.).

It is well-known that the strength of egg shells varies from flock to flock. To assess this, a random sample of 30 eggs was collected in the morning and again in the afternoon. Egg weight, shell deformation (strength estimate), and shell thickness were determined on each egg in this sample. The weight and shell thickness were determined on all of the checked eggs which were identified in any sample (except smashed losses). This allowed a comparison of the egg weight and shell thickness of normal and checked eggs from each flock.

RESULTS AND DISCUSSION

The results from the 26 individual flock studies were summarized and reported to each cooperating ranch. No attempt will be made to discuss these individually in this paper. The records were used to alert cooperating ranches when excessive breakage was observed.

The flocks used in this study were not selected at random; only ranches with mechanical egg collection equipment were included, and on these ranches the oldest flocks available were intentionally studied since they were more likely to demonstrate the parts of the mechanical collection system where breakage would occur.

The reader should keep this bias in mind. This selection procedure gave us very high breakage in a few samples.

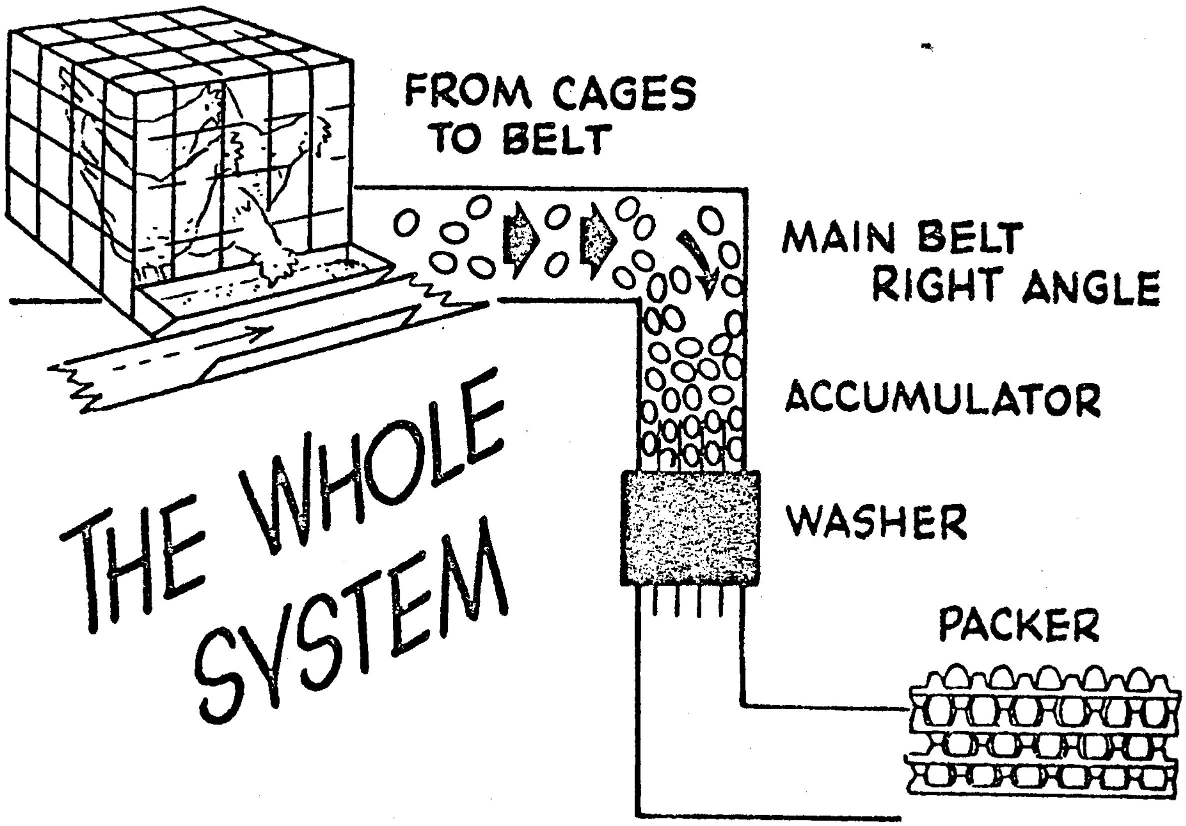

FIG. 1. SCHEMATIC DIAGRAM OF MECHANICAL EGG COLLECTION SYSTEM

A sample of eggs was collected from the collection belt in front of the cage or, in flat-deck systems, before the belt reached the transfer point to the main belt. These are called tray samples and an average of 3.18% breakage was found at this point (figure 2). The level of breakage in these 26 samples ranged from 0.30% to 8.17%. This was related to shell thickness as shown in figure 1, which demonstrates a highly significant negative correlation (r = -0.53) between mean shell thickness and percent breakage in the morning tray samples. Cage design was also an important factor with significantly higher tray sample breakage among flat-deck systems (3.76%) compared to systems where eggs from a single row of cages rolled onto the belt (2.37%). These results (table 3) are similar to those reported by Bezpa et al (1972), who found 4.57% breakage at point of lay in flat-deck cage systems and 2.83% in stair-step cage systems. The higher tray breakage occurring in flat-deck systems is apparently due to the greater probability for collisions on the belt, with eggs rolling onto the belt from two sides and with more eggs on the belt. The classification of check types (table 4) showed that line and collision checks were the most prevalent check types in tray samples. Of the 3.18% cracked eggs found in the tray samples, 0.75% were damaged beyond salvage and were classified as loss eggs.

Egg breakage was also determined on samples of eggs which had been packed into flats at the end of the collection system, designated as all-the-way samples. Here an average of 6.34% breakage was found with a range in samples from 0.67% to 24.50% (table 5). Loss eggs at this point averaged 1.64%. This represents approximately a doubling in egg damage due to mechanical collection, washing (in some systems), and packing. Mechanical collection increased the incidence of line checks more than other types of checks.

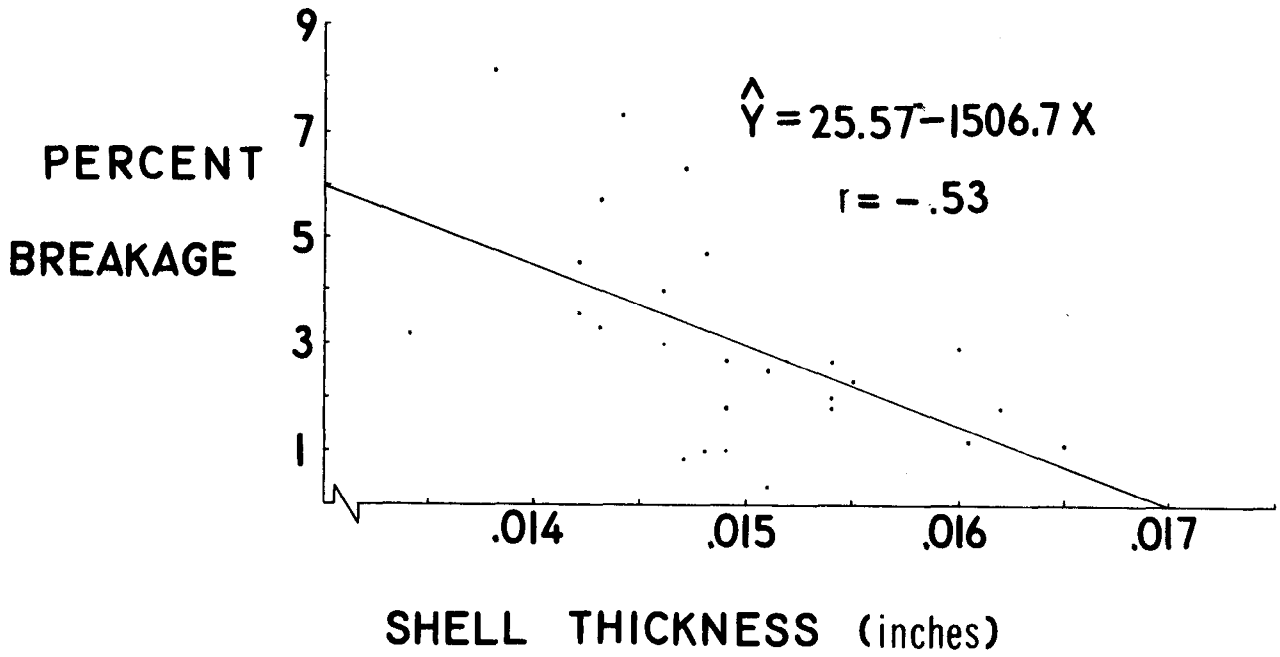

FIGURE 2: RELATIONSHIP OF MEAN SHELL THICKNESS TO PERCENT BREAKAGE--MORNING TRAY SAMPLE

Table 3. Effect of cage design on tray breakage

Cage type	Number sampled	Tray breakage (%)[1/]
Flat-deck	14	3.76a ± 0.56[2/]
Single row	11	2.37b ± 0.52

1/ Means with different letters are significantly different ($P < 0.01$).
2/ Mean ± Standard Error.

Table 4. Egg breakage by type of check in morning tray samples - 26 flocks

Type of check	Breakage (%)		Loss eggs (%)
	Mean[1/]	Range in samples	
Smashed	0.45b	0.00 - 1.50	0.45
Line	1.13a	0.17 - 4.33	0.01
Collision	1.03a	0.00 - 2.50	0.09
Wire	0.16b	0.00 - 0.50	0.04
Toe	0.41b	0.00 - 1.17	0.15
Total	3.18	0.33 - 8.17	0.75

1/ Means with different letters are significantly different ($P < 0.01$).

Table 5. Egg breakage by type of check in morning all-the-way samples - 26 flocks

Type of check	Breakage (%) Mean[1/]	Range in samples	Loss eggs (%)
Smashed	0.99c	0.00 - 6.00	0.98
Line	2.72a	0.17 - 9.27	0.04
Collision	1.88b	0.33 - 9.27	0.16
Wire	0.09d	0.00 - 0.33	0.04
Toe	0.65c	0.00 - 3.33	0.42
Total	6.34	0.67 - 24.50	1.64

1/ Means with different letters are significantly different ($P < 0.05$).

Of the 26 flocks surveyed, the eggs from 18 flocks on 9 ranches were washed during collection. A comparison of the effect of washing is shown in table 6. For this comparison, three samples with extreme breakage were not used since the cause of this breakage was determined to be from other parts of the collection systems. The difference between the tray breakage and the all-the-way breakage was then determined for each flock, and the systems with washers were found to have 1.53% higher average breakage (2.62 vs 1.09%). The washer breakage (determined by the difference between samples) agrees closely with the 1.47% breakage which was found in the step-by-step analysis of the systems (table 7). Only 9 washers were checked as part of the step-by-step procedure, but one washer was checked with the eggs from 2 flocks. This accounts for the 10 samples reported in table 7. Our results are higher than the washer breakage of 0.7% reported by Bezpa et al. (1972) but less than the 2.0% reported by Brooks et al. (1970).

Table 6. Effects of egg washing on breakage in system

Systems with	Number sampled	Breakage (%) Tray (A)	All-the-way (B)	Difference from handling[1/] (B-A)
Washer	15	2.87 ± 0.44[2/]	5.49 ± 0.79[2/]	2.62
No washer	8	2.50 ± 0.45	3.59 ± 0.79	1.09

1/ Significantly different ($P < 0.05$).
2/ Mean ± Standard Error.

Table 7. Results of step-by-step analysis[1/]

Component	Number sampled	Breakage (%) Mean	Range in samples	Loss eggs (%)
Elevator or brushes	15	1.18	0.17 - 3.90	0.43
Main crossbelt	13	0.97	0.00 - 7.41	0.62
Elevator/de-escalator	4	0.26	0.00 - 0.69	0.00
Accumulator	5	0.58	0.17 - 1.38	0.27
Washer	10	1.47	0.52 - 2.55	1.22
Packer	17	1.46	0.17 - 6.72	0.47

1/ No statistical comparisons were made on these data.

Egg weight and shell thickness were determined on the broken eggs in the all-the-way samples and on a random sample of 30 control eggs collected from the same flock. The results of this study show that checked eggs are slightly heavier than the average or, perhaps, that heavier eggs are more likely to break during handling (table 8). There was no difference between egg weight means for the various classes of checks, but shell thickness means for these check types were significantly different (table 8). These data indicate that thin-shelled eggs are more likely to become smashed or incur a collision-type check during collection. This table also shows that loss eggs had thinner shells than other checks and that a random sample of unbroken eggs from these flocks had thicker shells than either of the former. Thus, shell thickness is an important factor influencing the incidence of egg breakage under commercial conditions.

Table 8. Egg weight and shell thickness of different types of eggs (all-the-way sample - 26 flocks)

Type	Egg weight	Shell thickness
	(gram)	(in. x 1000)
Smashed	56.0a[1/]	13.29c[1/]
Line check	58.5a	13.82ab
Collision check	59.4a	13.53bc
Wire check	60.1a	13.64ab
Toe check	58.8a	13.93a
All checks	59.9a[1/]	13.67b[1/]
Control eggs	59.4b	14.68a
Loss eggs	n.a.	13.47c

1/ Means in this group with different letters are significantly different ($P < 0.05$).

The probability that an egg in a certain thickness range will break before reaching the egg flat was calculated from the thickness measurements made on broken and control egg samples (figure 3). These data clearly demonstrate than an egg thinner than 0.013 inches has a high probability of breakage and that for eggs with thicker shells, breakage rate is less affected. These results demonstrate the importance of determining the percentage of very thin shelled eggs as well as the mean thickness when assessing shell quality in a flock.

In the 18 flocks which were sampled at the morning and afternoon collections, we found significantly higher egg breakage in the afternoon samples--2.97% vs 3.60% (table 9). The afternoon samples also had significantly thinner shells, and these shells were weaker as demonstrated by significantly greater average deformation under a 500-gm. load (table 9). These results are predictable since Berg (1945) has demonstrated that the first and last eggs in a clutch have thicker shells than the intervening eggs. Since the first and last eggs in a clutch would most likely be laid early and late in the day, respectively, they would usually be present in the morning collection.

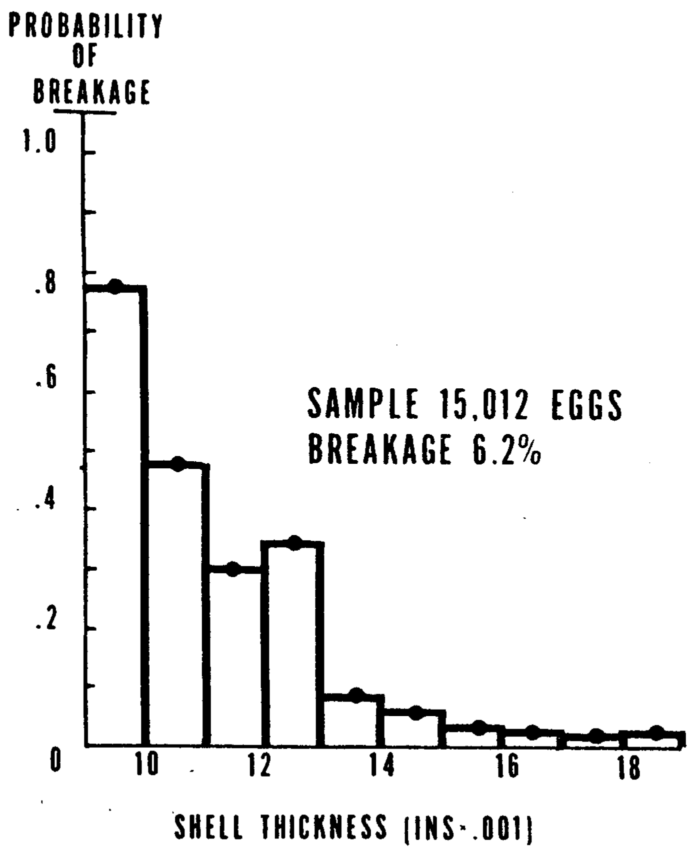

FIG.3. THE RELATIONSHIP OF SHELL THICKNESS TO THE PROBABILITY THAT AN EGG WILL BREAK DURING MECHANICAL COLLECTION.

Table 9. Effect of time of collection on egg breakage, shell thickness, egg weight and deformation of eggs collected from cage trays - 18 flocks

Sample	Egg breakage 1/	Shell thickness 1/	Egg weight 1/	Deformation 1/ 2/
	(%)	(in. x 1000)	(gms)	(microns)
Morning	2.97a ± 0.48 3/	14.94a ± 0.197 3/	59.2a ± 0.76 3/	24.3a ± 0.60 3/
Afternoon	3.60b ± 0.67	14.49b ± 0.157	59.9a ± 0.98	26.3b ± 0.64

1/ Means with different letters are significantly different ($P < 0.05$).
2/ Shell deformation under 500 gm. load using Marius instrument.
3/ Means ± Standard Error.

The results of the step-by-step procedure for determining egg breakage in various components of the collection system are not directly additive since systems differ in design. The results do give some general insights into the breakage caused by various system components and, therefore, are summarized in table 7. The reader is cautioned to consider that the division of systems into components (e.g. accumulator, washer, etc.) was quite arbitrary and in some systems it was not possible, for example, to separate the accumulator from the washer or packer. The range in breakage in table 7 is interesting because the lowest values show how effectively eggs can be handled when conditions are optimum and the highest how high the breakage can be when shells are weak and/or equipment is malfunctioning.

A comparison was also made of the various packing systems which were in use on the ranches studied (table 10). There was no statistical difference in the mean breakage for the four systems studied. It appeared that hand packing resulted in lower breakage, but since this was used on only 2 ranches, a meaningful statistical comparison was not possible. However, Bramhall, et al. (1972) found an average of 2.2% broken eggs after hand collection under commercial conditions. Their study included 13 flocks ranging in age from 31 to 111 weeks. This is slightly less damage than we found in tray samples when the eggs from a single cage row rolled onto one belt. This should have been a very similar sample except that we intentionally selected the oldest flocks available and collected the eggs very carefully to avoid any breakage. Perhaps a more important factor is that hens are usually allowed less cage space when mechanical collection is used. This is due to an attempt by management to distribute the high investment cost over more hens; the result is a higher egg density in the trays and a greater opportunity for collision checks to occur there. The latter could easily account for the higher tray breakage which we observed as compared to Bramhall et al. (1972) in single-row tray samples. The data of Bramhall et al (1972) agree very

Table 10. Egg breakage by packer type 1/

Packer type	Number sampled	Breakage (%) Mean	Range in samples
A	6	1.77 ± 1.03 2/	0.17 - 6.72
B	5	1.38 ± 0.27	0.85 - 2.08
Vacuum lift	3	1.43 ± 0.42	0.84 - 2.25
Hand pack	2	0.59 ± 0.08	0.51 - 0.67

1/ Means not statistically different ($P < 0.05$).
2/ Mean ± Standard Error.

well with our findings for hand collection and indicate that eggs can be hand collected with less than 1% breakage.

It therefore appears that the mechanical systems presently used in California cause an increase of 2 to 4% in shell damage. If one assumes that the value of damaged eggs is reduced by 24¢ per dozen, this is a loss of 14¢ to 28¢ per case attributable to mechanical collection.

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