Breakout Analyses Guide for Hatcheries

Reviewed by Jeanna L. Wilson, Extension Poultry Scientist
Original manuscript by Joseph M. Mauldin, Former Extension Poultry Scientist

To improve the performance of a hatchery breeder operation, the baseline quality must first be determined. This bulletin outlines the most productive quality procedures that can be implemented in a quality control program -- the breakout analyses.

There are three types of breakout analyses that can be performed on hatching eggs. The first opportunity for a breakout analysis is with fresh hatching eggs. The second opportunity occurs with candling eggs at 7 to 12 days of incubation and the final breakout comes at hatch time. All three methods are fairly simple and each one provides a powerful means of problem solving that can strengthen a hatchery-breeder quality control program.

The three procedures for breakout analysis are described so that a quality control person can easily implement and use them to troubleshoot hatchery or breeder flock problems. Each method has advantages and disadvantages when compared to the other methods.

Fresh Egg Breakout
The fresh egg breakout has the advantage of being the quickest way to estimate fertility in the breeder flock. It is useful when a flock begins to lay eggs or if a flock has been treated for a disease or fertility problem. Fertility can be determined on the day the eggs are laid rather than (having to wait until after the egg storage time and the incubation time for the opportunity for candling or hatch day breakout...not clear) For example, if there is a storage time of one week and fertility is determined by hatch day breakout analysis, then the information regarding flock fertility is four weeks behind the flock performance. Management changes, in this case will take a long time to incorporate. However, there are numerous disadvantages associated with the fresh egg breakout.

The most serious disadvantage of a fresh egg breakout is that it only provides information on fertility estimates. A company relying on the fresh egg breakout analysis will not gain valuable information on other important sources of reproductive failure such as embryonic mortality, contamination, pips, hatch of fertiles and many others. A second disadvantage is the loss of valuable hatching eggs due to the procedure. However, a relatively small sample size is normally used for fresh egg breakouts. Because valuable hatching eggs must be used, the sample size rarely exceeds 100 eggs, resulting in the third disadvantage errors of prediction. Rarely are samples of fresh eggs large enough to provide an adequate sample size, leading to sampling error. The other two methods of breakout require the evaluation of several hundred eggs, but only problem eggs in a sample are evaluated. A fourth disadvantage of a fresh egg breakout is that it is more difficult to distinguish between fertility and infertility in fresh eggs than when eggs have been incubated for several days. Distinguishing fertiles from infertiles is certainly not impossible after a little practice. To correctly distinguish the differences in fertile and infertile eggs, the egg contents must be poured out and the germinal disc must be found.

There are three criteria that should be used to determine fertility/infertility of a germinal disc; shape, size, and color intensity.

1. **Shape:** Upon close observation, a blastoderm (indicating fertility) is always round (i.e. almost perfectly uniform and symmetrical). Hatchery personnel often refer to this shape as a "doughnut." The doughnut appearance is seen as a white symmetrical ring with a clear area in the center of the ring (Plate 1). Sometimes a white dot will be present in the center of the clear area. The blastodisc (indicating infertility) is rarely perfectly round, and has jagged edges. There are usually more vacuoles (bubbles) present in the periphery of the blastodisc than the blastoderm (Plate 2).
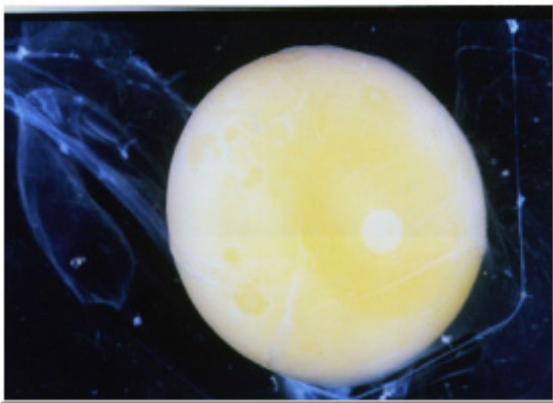

Plate 1. A fertile egg   Plate 2. An infertile egg

2. **Size:** The blastoderm is almost always larger in appearance (one- quarter to one-third larger) than the blastodisc.
3. **Color Intensity:** The blastoderm almost always appears to be a less intense color of white than the blastodisc. The blastodisc appears as more of a small, intense white spot on the surface of the yolk. Sometimes the blastodisc is granulated. Instead of one white spot, there may be several clumped white spots.

For learning the technique of distinguishing between fertile and infertile germinal discs, it is helpful to make side by side comparisons of eggs known to be fertile and eggs known to be infertile. It may help to place the yolks in clear petri dishes and gently compress the lid down onto the germinal discs. This makes the discs stand out to allow comparisons of shape, size and color features. The beginner should use a magnifying glass to help make these determinations.

During a fresh egg breakout, it is important to have a sample size of at least 100 eggs per flock. Because of the disadvantages involved in the fresh egg breakout, this procedure is not recommended unless a quick fertility check is desired. Candling and/or hatch day breakouts should be done more routinely (every one or two weeks).

Candling Breakout Analysis
The candling breakout analysis offers the most accuracy in determining fertility. It is also useful in determining other sources of breeder flock or hatchery failures, such as percentages of eggs set upside down, cracked and embryos that have died early. Many hatchery managers incorporate the candling breakout procedure into their quality control program to monitor the week-to-week status of their breeders throughout the life of the flocks. Candling can be done as early as five days of incubation, but errors in candling often occur at this time. Because of the rapid growth rate of the embryos during the second week of incubation, very few, if any, candling errors are made on the ninth or tenth day of incubation.

There are two methods of candling that can be used. The fastest method involves the use of a table or mass candler. An entire tray of hatching eggs may be placed on the mass candler and examined with one observation (Plate 3). Clear eggs consist of infertiles and eggs with early dead embryos and emit more light than eggs with viable embryos. Clear eggs are removed from the tray to be broken out. Candling with a spot candler is a little slower, but it is more accurate for several reasons (Plate 4). By examining each egg individually with a spot candler, less candling errors are committed and eggs set upside down or cracked are much easier to distinguish than with the mass candler.
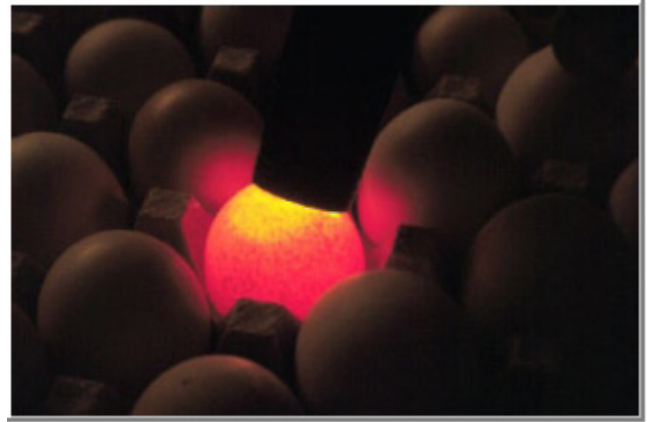
It is important to record the information of eggs set upside down, farm cracks and cull eggs. All companies have varying qualities of hatching egg producers. The producers that are not careful about sending the hatching eggs to the hatchery with the blunt end up cost the company a lot of money in lost hatchability and chick quality. This becomes even more important in hatcheries using in ovo vaccination. Practically, all the embryos contained in upside down eggs will be killed by the in ovo vaccination process because the needle impales the embryo. It is important to identify these individuals with a candling breakout analysis so that they can be encouraged to be more careful. The knowledge that a hatchery is enumerating upside down eggs will, in many cases, be enough to justify more careful egg collection.

For the candling and breakout procedure to be accurate, a sufficient sample size of eggs must be used for candling. A minimum of four trays per breeder flock is needed to ensure that estimates for fertility, eggs set upside down, farm cracks, and cull eggs are meaningful. Take eggs from different areas of the incubator racks/buggies. This will provide a more random sample which is desirable.

It is often suggested that candling estimates of fertility are the "true fertility." This is not correct. Candling samples of eggs only provide an estimate of true fertility. The only way to obtain the information of true fertility would be to candle every tray in a setting of a breeder flock. To do this would not be time efficient. Table 1 is an example form that may be used for the candling procedure. Included is an example of a candling breakout analysis. Examining these data it is revealed that fertility was excellent at 97.69% and that early embryonic mortality was good at 2.47%. However, egg collection and selection on the breeder farm appeared to be a little sloppy because farm cracks, upside down and cull egg percentages were all greater than 0.50%.

Table 1. 7-12 Day Candling and Breakout Analysis Form						
Date: 10/14/97		**Company:** Big Bird		**Hatchery Location:** Athens		
Flock #: 24		**Test:** No test		**Breeder Flock Hatch Date:** 12/27/97		
Breed:		Male X		Female Y		**Age (wks):** 38
tray #	eggs/tray	infertile	early dead	farms cracks	upside down	cull eggs
1	162	3	5	1	2	1
5	162	5	5			2
10	162	4	3	2	2	1
15	162	3	3	1		1
Totals:	648	15	16	4	4	5
Percents:		2.31	2.47	0.62	0.62	0.77

Fertility = 100 - % Infertile = 97.69%
Other Observations:

Hatch Day Breakout

You may be throwing away valuable information in your hatchery waste that could help solve hatchery and breeder flock problems, or improve hatchability and profitability. Unhatched eggs hold information that breeder and hatchery managers need. Without breaking eggs to gain this information, reasons for moderate to low hatchability are only guesses.

The hatch day breakout analysis involves sampling unhatched eggs from breeder flocks, and classifying them into the various causes of reproductive failure. The procedures for this valuable management tool are described below.

The hatch day breakout analysis should be performed at least once every two weeks on samples of eggs from all breeder flocks, regardless of hatchability performance or flock age. Even good hatching flocks should be monitored to get a true picture of hatchery and reproductive efficiency. Breakout analysis on all breeder flocks is critical in pinpointing problems in setters and hatchers; comparing breeder companies; evaluating flock or farm management; and compiling flock histories for production, fertility, hatchability and reproductive failure. Breakouts are also beneficial for trouble-shooting problems in production, egg handling and storage. For example, high numbers of early deads may indicate prolonged storage or storage at elevated temperatures, or inadequate egg collection procedures. In most hatcheries, the breakout should be performed on two consecutive hatch days to ensure that all breeder flocks are sampled.

Breakout Procedure

1. Immediately after the chicks are pulled, collect a minimum of four trays of eggs per breeder flock from different parts of a single setter.
2. Remove all unhatched eggs, including pips, from the hatching tray. Place them in filler flats with the large end up and record the flock number.
3. It is best when the breakout is done soon after the hatch rather than a day or two later. This gives a more accurate estimate of live versus dead in shell.
4. Record the number of cull and dead chicks left in the tray.
5. Break out the eggs and classify them into the appropriate categories of reproductive failure listed in Table 2 and Table 5.

Table 2. Data Collection - Hatch Day Breakout	
General	**Reproductive Failures**
Flock number	Infertiles
Flock age	Embryo mortality Embryo malpositions Embryo abnormalities
Male breed	Pipped, unhatched
Female breed	Cull eggs
Sample size, sample index	Farm and transfer cracks
Setter number, sample index, Hatcher number	Contaminated eggs
Management type (test)	Cull chicks
Hatchability	Upside-down

The best procedure is to break and peel the large end of the eggs since embryonic development will most often be located there. The alternative method of cracking the eggs over a pan is not as accurate because the embryo or germinal disc often rotates beneath the yolk and is difficult to locate. Cracking eggs also increases the likelihood of rupturing the yolk membrane (these membranes are weak after 21 days of incubation). When the yolk membrane ruptures, it is difficult to know if that egg contained an early dead embryo or was infertile.

Embryo Mortality Determination

There are some cases when the embryo or the blastodisc will not appear on the top of the yolk. When this occurs, rotate the egg and pour off some albumen so that the germinal disc (fertile or infertile) will appear at the top. If the embryonic development is still not found, the yolk may then be poured into an empty pan and examined.

The classifications of embryonic death may be as detailed as the hatchery manager wishes. It must be kept in mind when starting a breakout program that the quality control person need not be an embryologist. In most cases, sufficient information is obtained by classifying the dead embryos by the week that death occurred (i.e., first, second, or third). This is easily done after a few practice runs.

The clarity of the development is not as good in eggs broken after 21 days of incubation as when eggs are broken while the embryos are still alive. However, with practice one can conduct an accurate breakout analysis by judging the embryos according to size and looking for some of the obvious changes in the developmental sequence (Table 3). A good training technique for someone not previously involved in breakout analyses would be to examine live embryos at different stages of development and compare them to the dead embryos obtained from unhatched 21-day incubated eggs, or embryos pictured in poster publications (Buhr and Mauldin, 1990; Mauldin and Buhr, 1991).

Table 3. Signs of Embryonic Development	
Day	**Signs**
1	Appearance of primitive streak and first somite
2	Appearance of amniotic folds; heart beats; blood circulation
3	Amnion completely encircles embryo; embryo rotates to left side
4	Eye pigmented; leg buds larger than wing
5	Appearance of elbows and knees
6	Appearance of beak; voluntary movement; demarcation of digits and toes
7	Comb growth begins; appearance of egg tooth
8	Feather tracts prominent; upper and lower beak equal in length
9	Bird-like appearance; mouth opening appears
10	Digits completely separated; toe nails
11	Comb serrated clearly; tail feathers apparent; eye lid oval
12	Eyelids almost closed and elliptical
13	Appearance of overlapping scales; embryo covered with down; eye lid slit opening
14	Embryo aligned with long axis
15	Small intestines taken into abdomen
16	Feathers cover body
17	Head between legs
18	Head under right wing
19	Amniotic fluid disappears (embryo swallws it); yolk sac half withdrawn
20	Yolk sac completely drawn into body; beak pips into air cell
21	Shell pipping; normal hatching

Identifying Fertility in 21-Day Incubated Eggs

Fertility of a 21-day incubated egg can be identified by looking for signs of development and by examining yolk color and albumen consistency. The two statements that follow relate to the identification of very early deads, positive development, and infertile eggs after 21 days of incubation.

Generally speaking, an infertile yolk will be a brighter yellow than a fertile yolk. The albumen of infertile eggs is thicker than the albumen of fertile eggs. An infertile yolk is held in the center of the egg while a fertile yolk will sink near the point end.

Although these statements are correct, there may be instances when they are not fail safe. To accurately classify the egg, the presence or absence of early embryonic development must be established. Most eggs can be classified as soon as the tops of the shells are peeled back. Others require closer inspection. Be careful not to let blood spots, meat spots or yolk mottling result in classifying an infertile egg as fertile.

Another pitfall is that most embryos that die during the second week of incubation look dark and are often mistaken for contaminated eggs. The dark appearance results from the breakdown of the blood in the tremendous vascular system of the extra-embryonic membranes. Most contaminated eggs will be malodorous which will help to classify them. Second week embryonic mortality may look contaminated; however, they should only be classified as contaminated when they emit an odor.

Keep Accurate Records

It is necessary to collect general and reproductive failure data to provide a basis for analysis. Building a data base of information enables the evaluation of reproductive efficiency by flock and breeder and it is an excellent diagnostic tool when problems arise in the hatchery or breeder flocks. Also, the influences of flock management, field and incubation equipment can be measured by studying their effects on fertility, hatchability and reproductive failure.

The Hatch Day Breakout Analysis form is basic for the evaluation of reproductive performance (Table 4). In this data collection form all the reproductive failures are enumerated, totaled and the percentages are calculated.

Table 4. Hatch Day Breakout Analysis Form												
Date: 10/14/97	**Company:** Big Bird			**Flock #:** 42						**Test:** No test		
% Egg Production: 73.8	**Hatchery Location:** Athens			**Breed:**		Male X	Female Y			**Age (wks):** 38		
Breeder Flock Hatch Date:	**# Set:** 28,600			**Actual Hatch %:** 80.98						**Setter #:** 16		
		dead embryos					cracks					
# eggs/tray	infert	1-7	8-14	15-21	pipped unhatched	cull chicks	farm	trans	cont	cull eggs	small end up
168	20	8		1	1		1		2	1	
168	13	9		2	5	2		1	1	1	1
168	11	5	1	5		1	1	1		2	
168	16	6	1	3	1	2			2	1	1
Totals: 676	50	28	2	14	7	5	2	2	5	5	2
Percents:	7.44	4.17	0.30	2.08	1.04	0.74	0.30	0.30	0.74	0.74	0.30
Fertility: 92.56						Estimated Hatch: 81.85					
Sample Index: 0.87						% Hatch of Fertiles: 87.49					
Spread: 11.58						Shell Quality: OK					
Malformations: None											

From these data reproductive efficiency measures such as fertility, percent hatch of fertiles, spread, estimated hatchability, and the sample index can be generated (Table 5). The example calculations generated in Table 5 were taken from the example data provided in Table 4.

Table 5. Examples for Calculating Reproductive Efficiency Values	
Formula:	% Fertility = 100 - (# infertiles ÷ sample size) x 100
Example:	100 - (50 ÷ 672) x 100 = 92.56%
Formula:	% Hatchability = (# hatched ÷ # set) x 100
Example:	(23,160 ÷ 28,600) x 100 = 80.98%
Formula:	% Hatch of Fertiles = (Hatchability ÷ Fertility) x 100
Example:	(80.98 ÷ 92.56) x 100 = 87.49%
Formula:	Spread = Fertility - Hatchability
Example:	92.56 - 80.98 = 11.58
Formula:	% Estimated Hatchability = 100 - % Reproductive Failures
Example:	100 - (7.44 + 4.17 + 0.30 + 2.08 + 1.04 + 0.74 + 0.30 + 0.30 + 0.74 + 0.74 + 0.30) = 81.85%
Formula:	Sample Index = % Estimated Hatchability - % Hatchability
Example:	81.85 - 80.98 = 0.87

By examining the results of the example provided, an analysis of the problem areas of Flock #42 can be understood. This 38 week old flock should have hatched considerably higher than 80.98%. First, the fertility of 92.56% should be about 4% higher for this age flock. Also, the percent hatch of fertiles was too low at 87.49%. This was caused by the elevated percentages noted for early deads (4.17%); contaminated (0.74%); and cull eggs (0.74%). It is obvious that the problems of low hatchability of Flock #42 stem from both breeder flock and hatchery. The low sample index of 0.87 reveals that the sample was reliable in providing an estimate of true performance.

The sample index listed in Table 5 is a valuable measure of how representative your sample is of the true reproductive performance of the entire setting of eggs. A large sample index (greater than 3.0) would indicate that the sample was not a good representation of actual performance. Small sample sizes will result in greater variation in the sample index. Calculating these measures is necessary in interpreting results and taking corrective action. It would be a mistake to take corrective management changes in the flock or hatchery due to breakout analysis results when the sample index is high.

Figures 1 and 2 depict how building a data base on the life of the flock can be useful in evaluating reproductive efficiency. Notice how the age of a flock causes considerable variation in fertility, hatchability and embryonic mortality. Plotting these data enables flock evaluations over time and enables a manager to determine the genetic potential of breeding stock by using the best hatching flocks as examples.
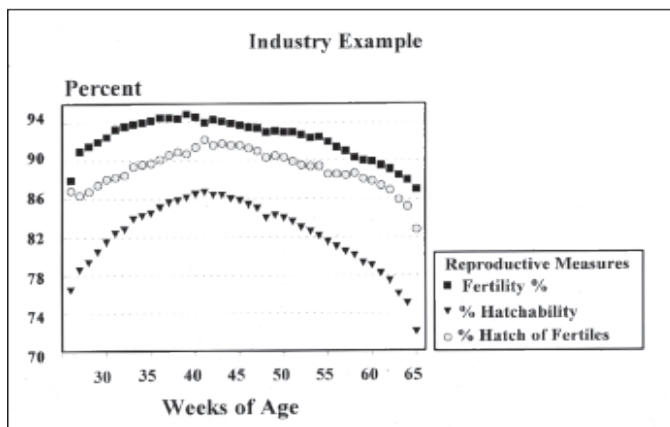

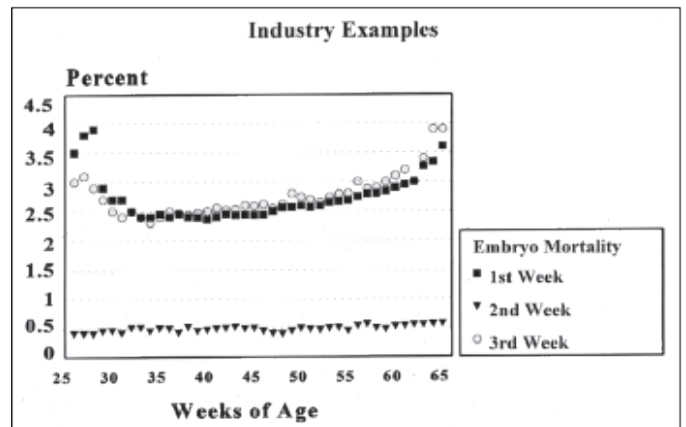**Figure 1.** Influence of flock age on reproductive performances (graph)

Figure 2. Influence of flock age on embryo mortality (graph)

Summary
Breakout analyses are useful hatchery management procedures that provide valuable information in isolating problems in the breeder and hatchery program. The brief amount of time involved in performing breakouts will pay large dividends by increasing reproductive efficiency. The hatch day breakout analysis separates and quantifies the problem areas that cause low hatchability. With this information, the hatchery and breeder managers can take appropriate corrective action to improve fertility, hatchability and chick quality.

References
Buhr, R. J., and J. M. Mauldin, 1990. Daily embryonic development of the chick. Poster for Misset World Poultry.

Mauldin, J. M., and R. J. Buhr, 1991. Embryonic mortality viewed at hatch time with live embryo comparisons. Poster for Misset World Poultry.

Mauldin, J. M., and R. J. Buhr, 1991. Analyzing hatch day breakout and embryonic mortality. Misset World Poultry.

Bulletin 1166   **Reviewed January 2014**